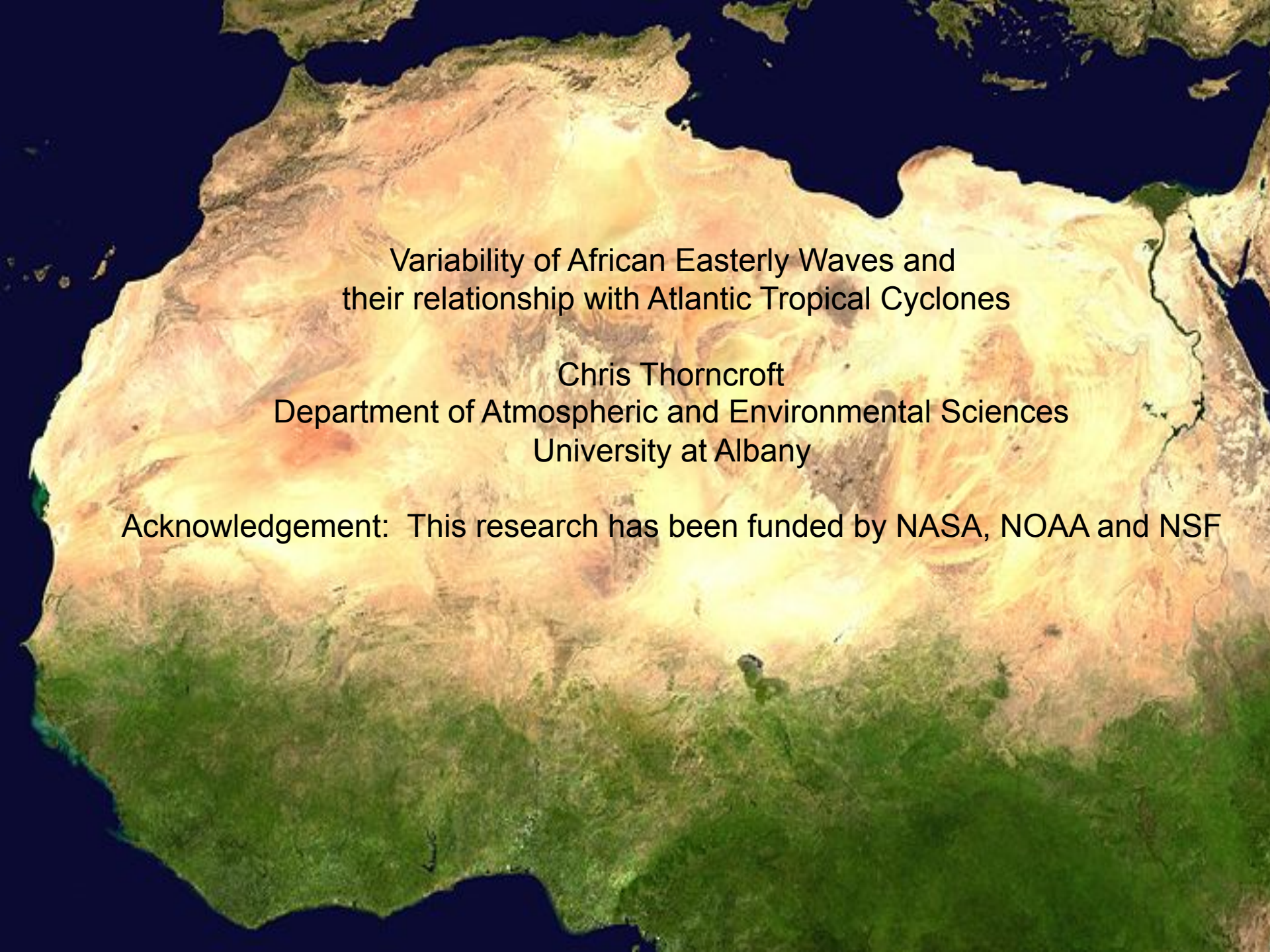


Variability of African Easterly Waves and their relationship with Atlantic Tropical Cyclones

Chris Thorncroft
Department of Atmospheric and Environmental Sciences
University at Albany

Acknowledgement: This research has been funded by NASA, NOAA and NSF

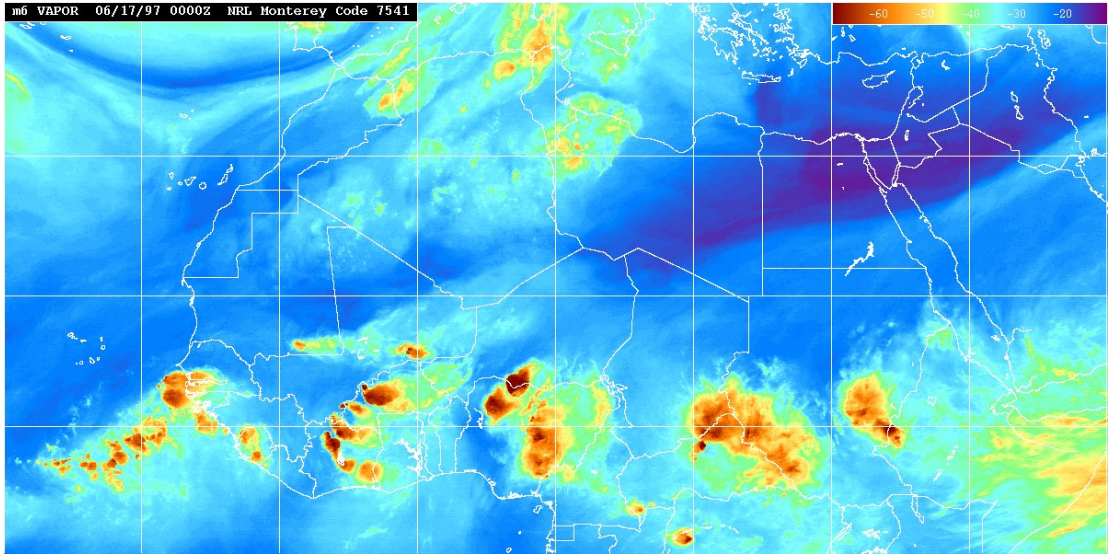
Variability of African Easterly Waves

(1) Background

(2) Variability in AEW Structures and their relationship to tropical cyclones

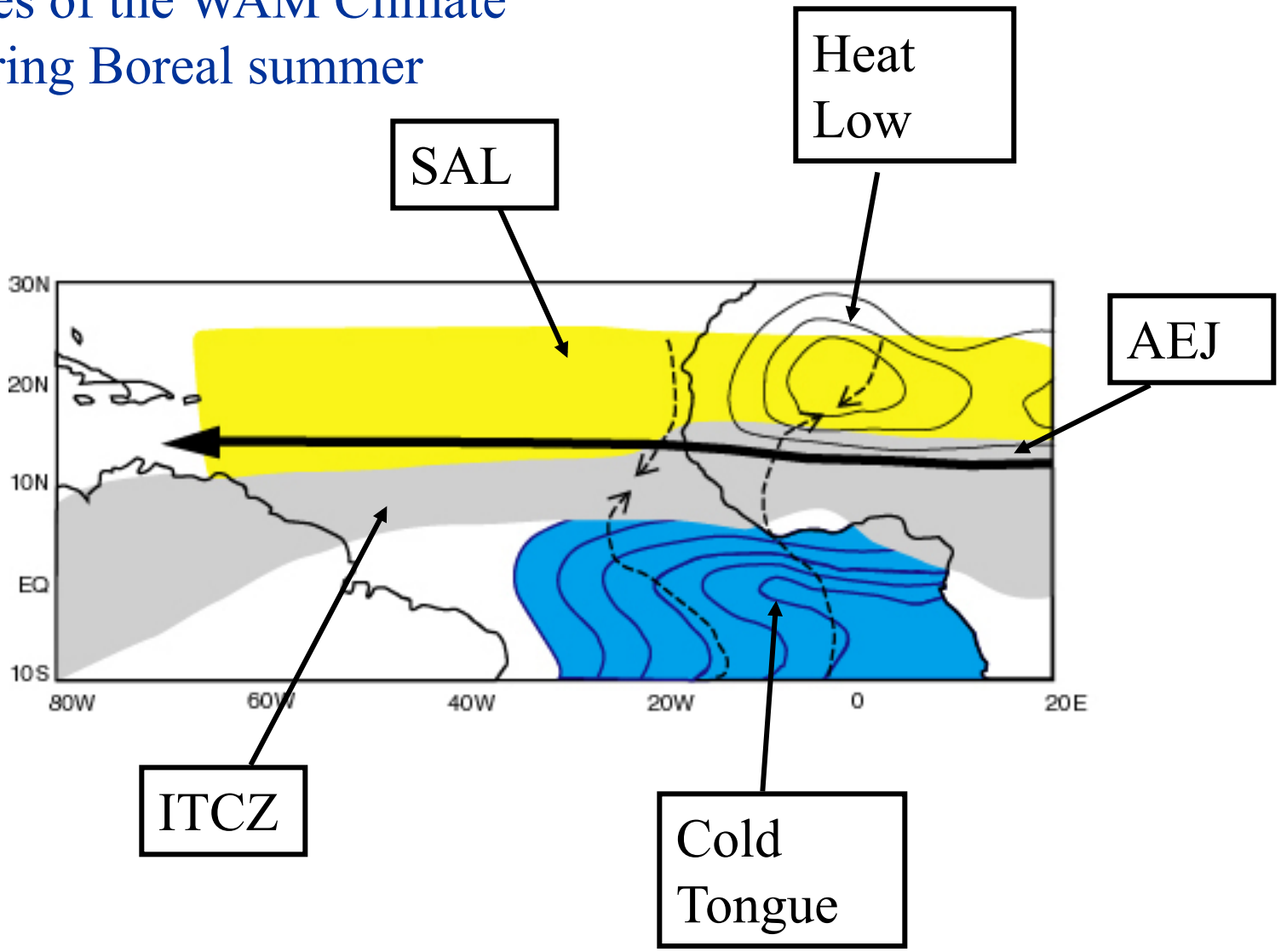
(3) Intraseasonal Variability of AEW-activity and its relationship to tropical cyclones

(4) Summary

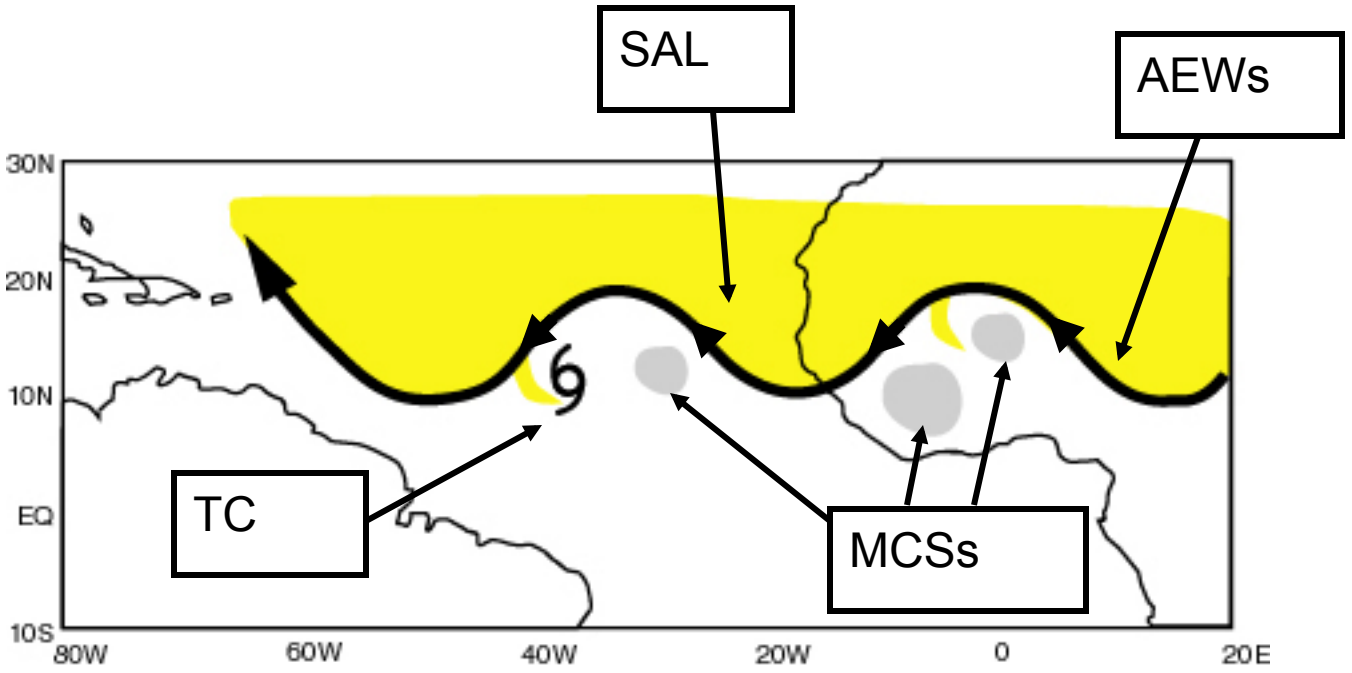


The Coupled Monsoon System

Key features of the WAM Climate System during Boreal summer

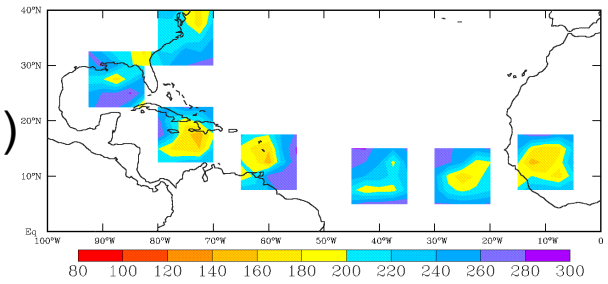


Key Weather Systems

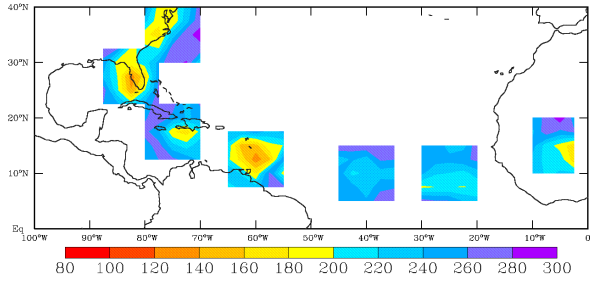


AEWs and TCs

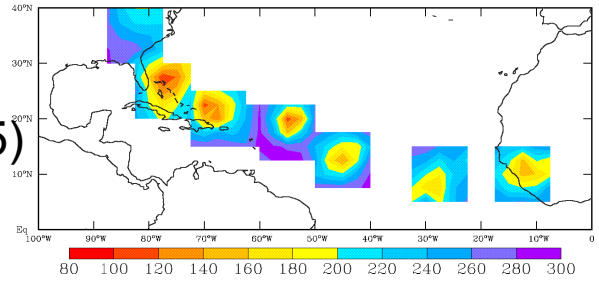
Bonnie (05)



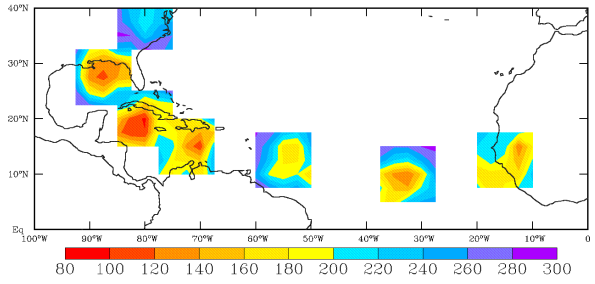
Charlie (05)



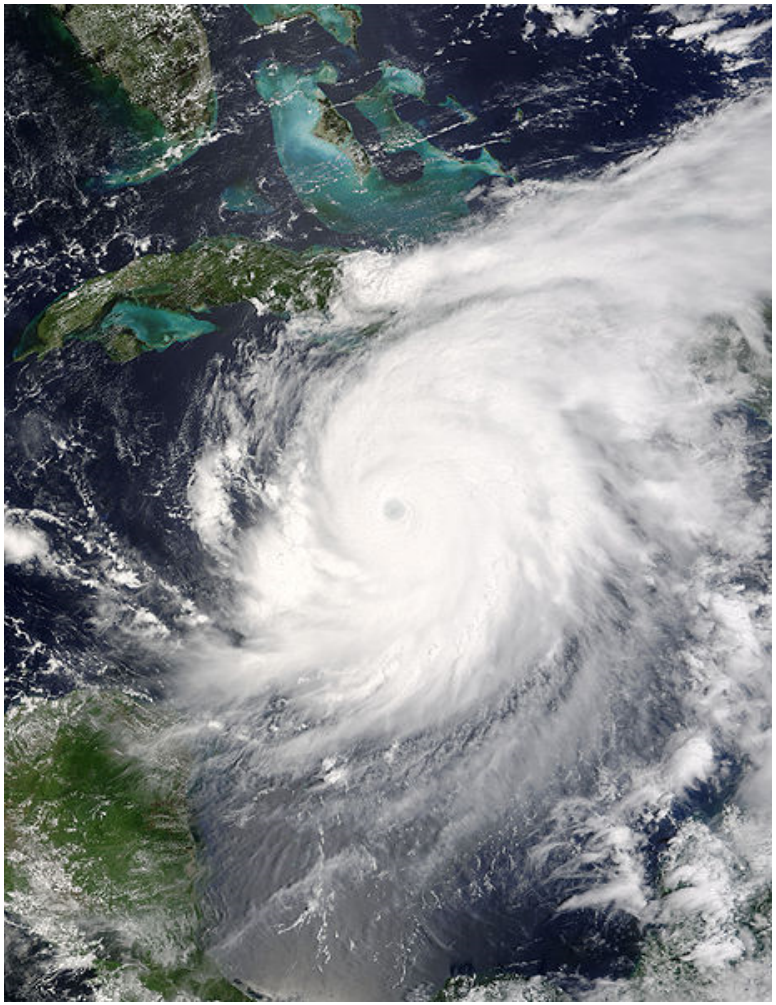
Frances (05)



Ivan (05)

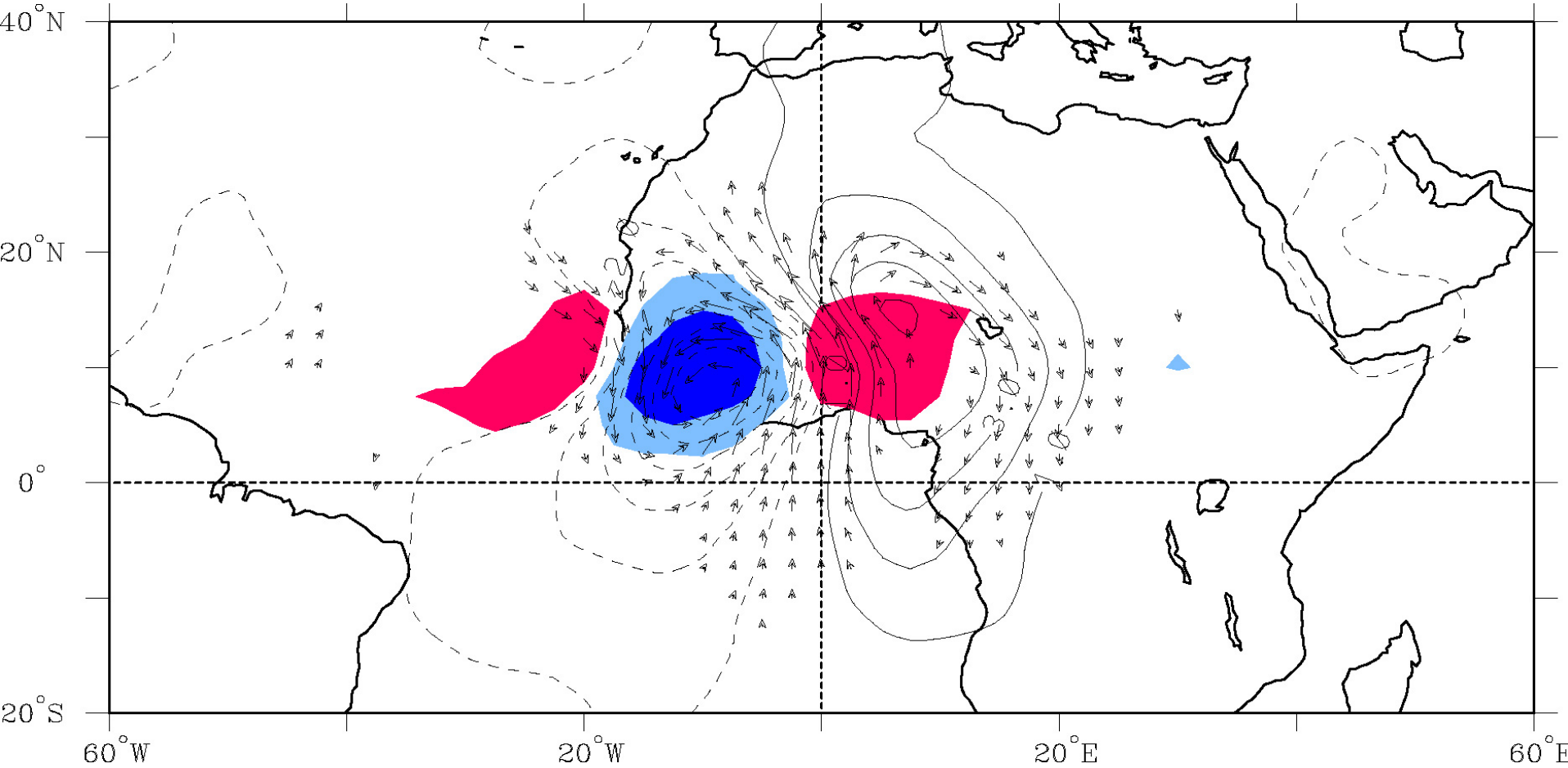


courtesy A. Aiyyer



Ivan close to the Yucatan

OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m^2) at 10°N, 10°W for June-September 1979-1993



Day 0

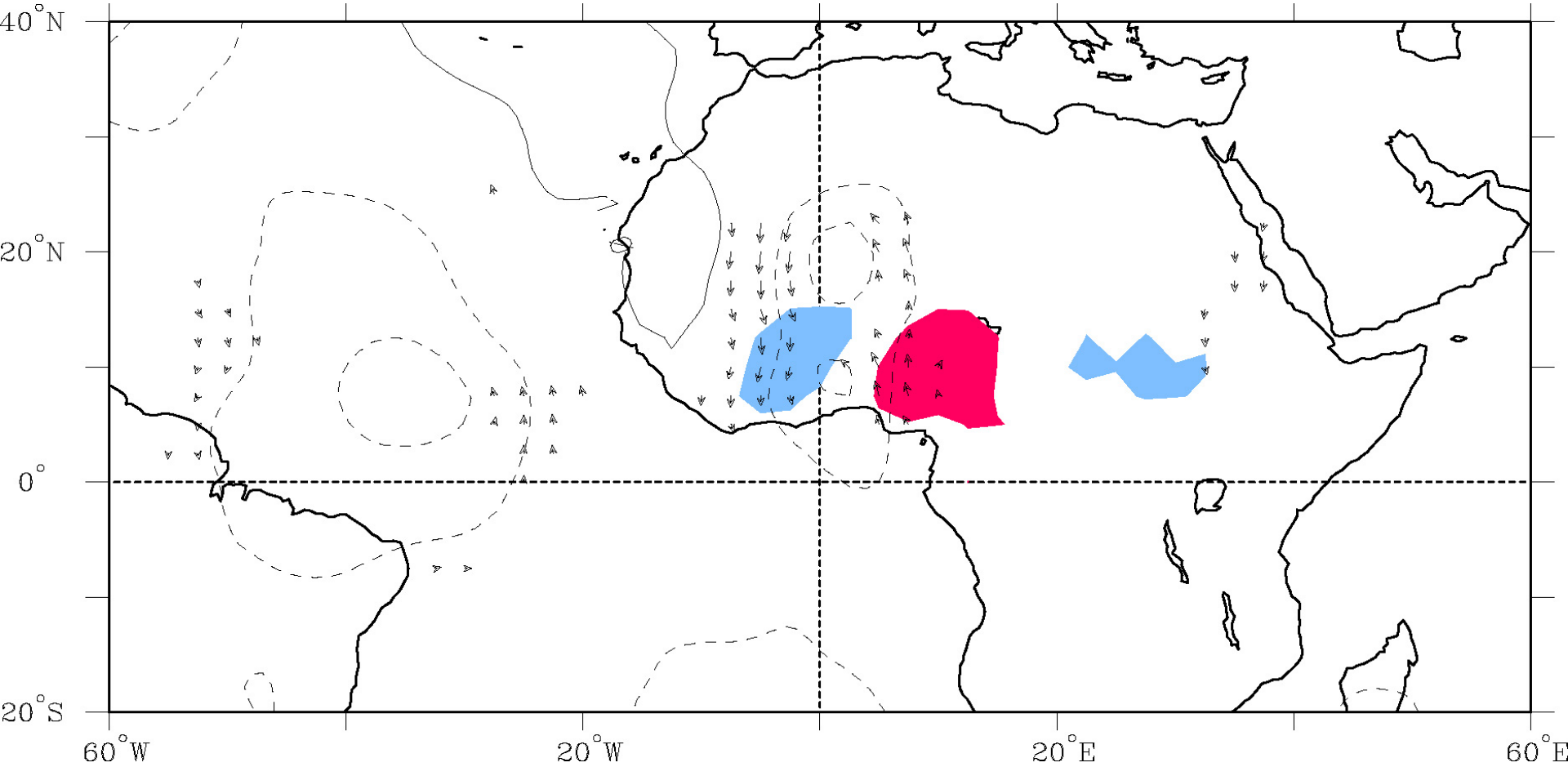
Streamfunction (contours 1 X 10^5 m^2 s^{-1})

Wind (vectors, largest around 2 m s^{-1})

OLR (shading starts at +/- 6 W s^{-2}), negative blue

Kiladis, Thorncroft, Hall (2006)

OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m^2) at 10°N, 10°W for June-September 1979-1993



Day-4

Streamfunction (contours 1 X 10^5 m^2 s^{-1})

Wind (vectors, largest around 2 m s^{-1})

OLR (shading starts at +/- 6 W s^{-2}), negative blue

Kiladis, Thorncroft, Hall (2006)

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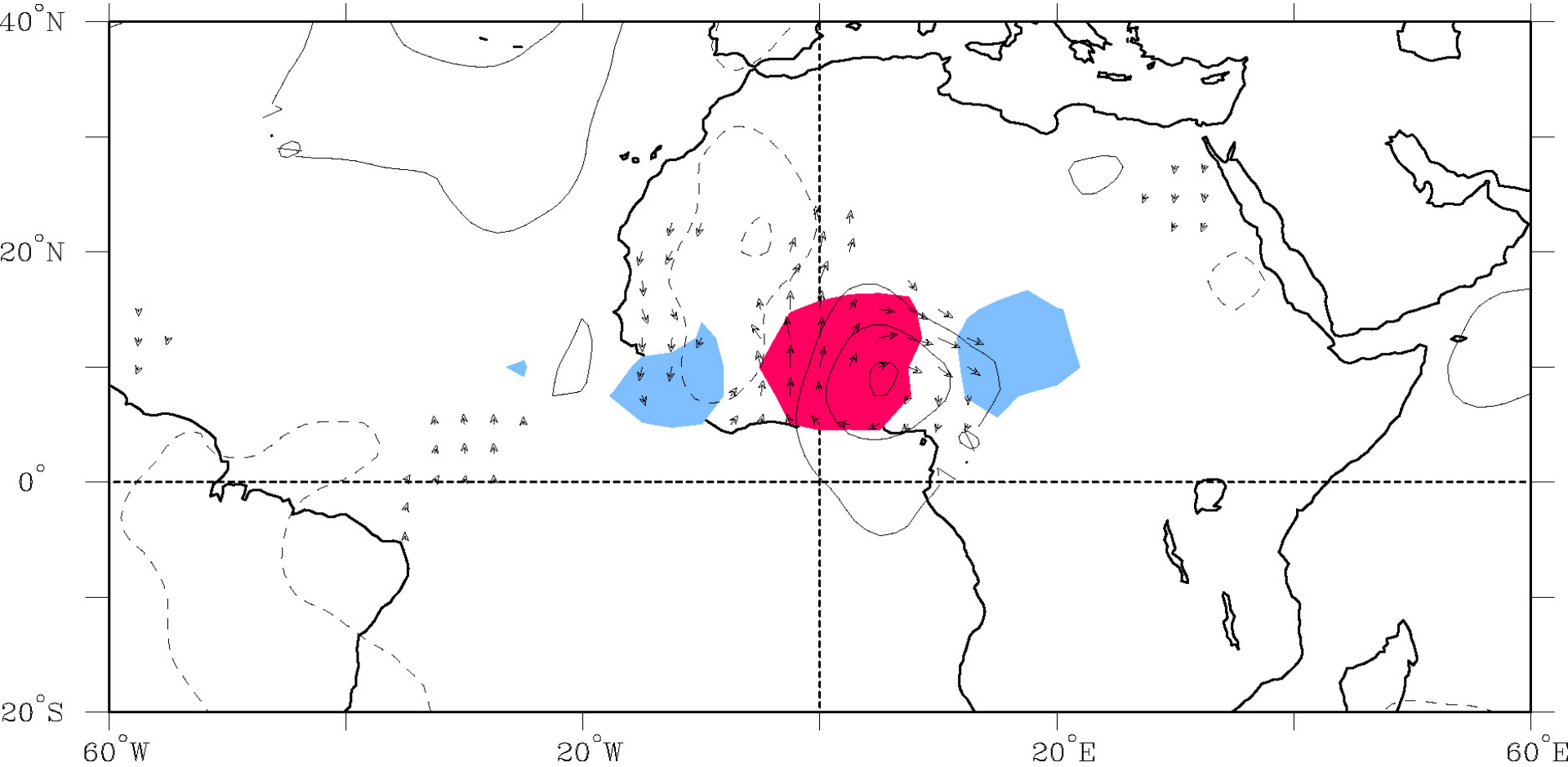

Day-3

Streamfunction (contours 1 X 10^5 m^2 s^{-1})

Wind (vectors, largest around 2 m s^{-1})

OLR (shading starts at +/- 6 W s^{-2}), negative blue

Kiladis, Thorncroft, Hall (2006)

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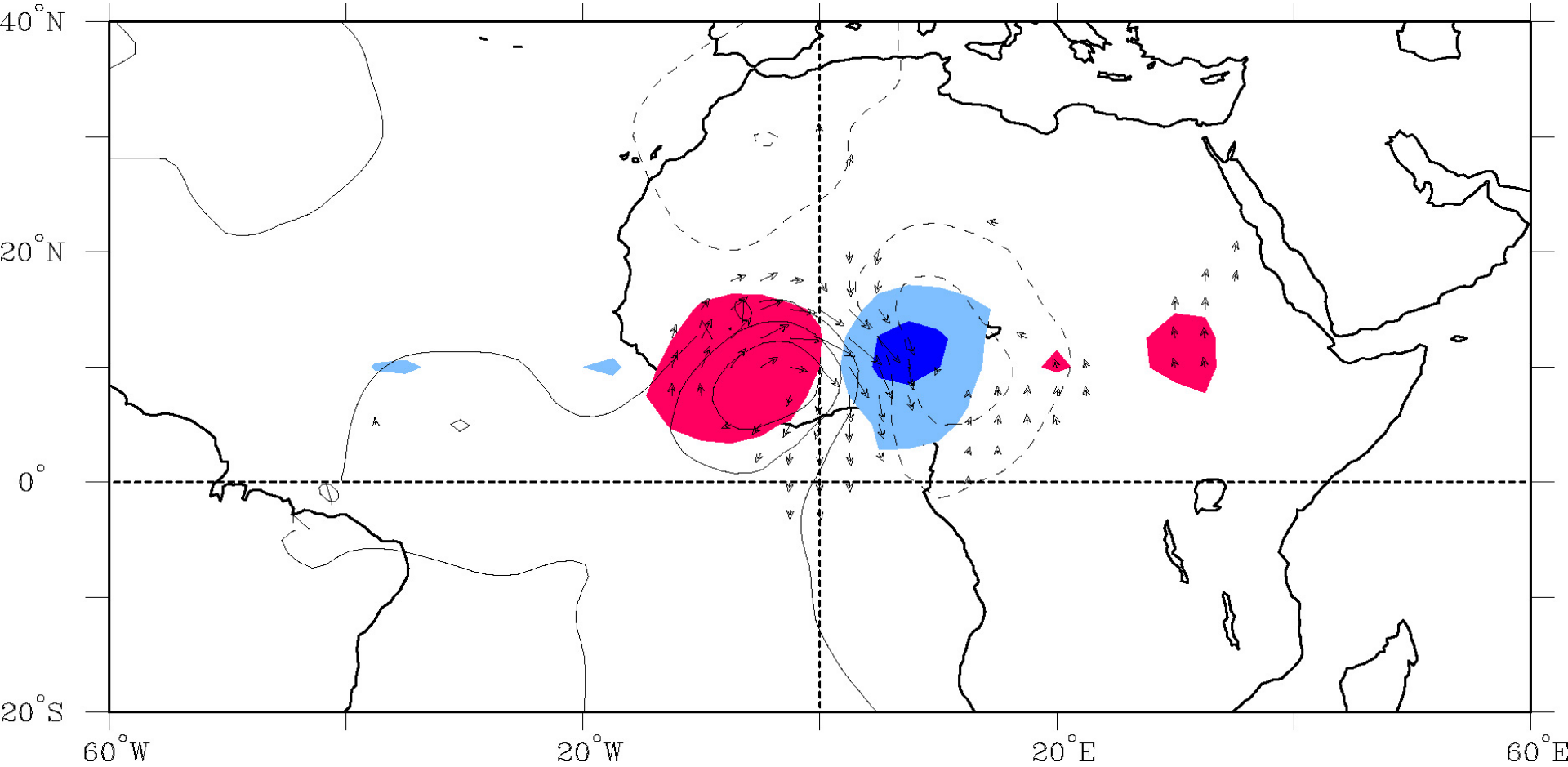

Day-2

Streamfunction (contours 1 X 10^5 m^2 s^{-1})

Wind (vectors, largest around 2 m s^{-1})

OLR (shading starts at +/- 6 W s^{-2}), negative blue

Kiladis, Thorncroft, Hall (2006)

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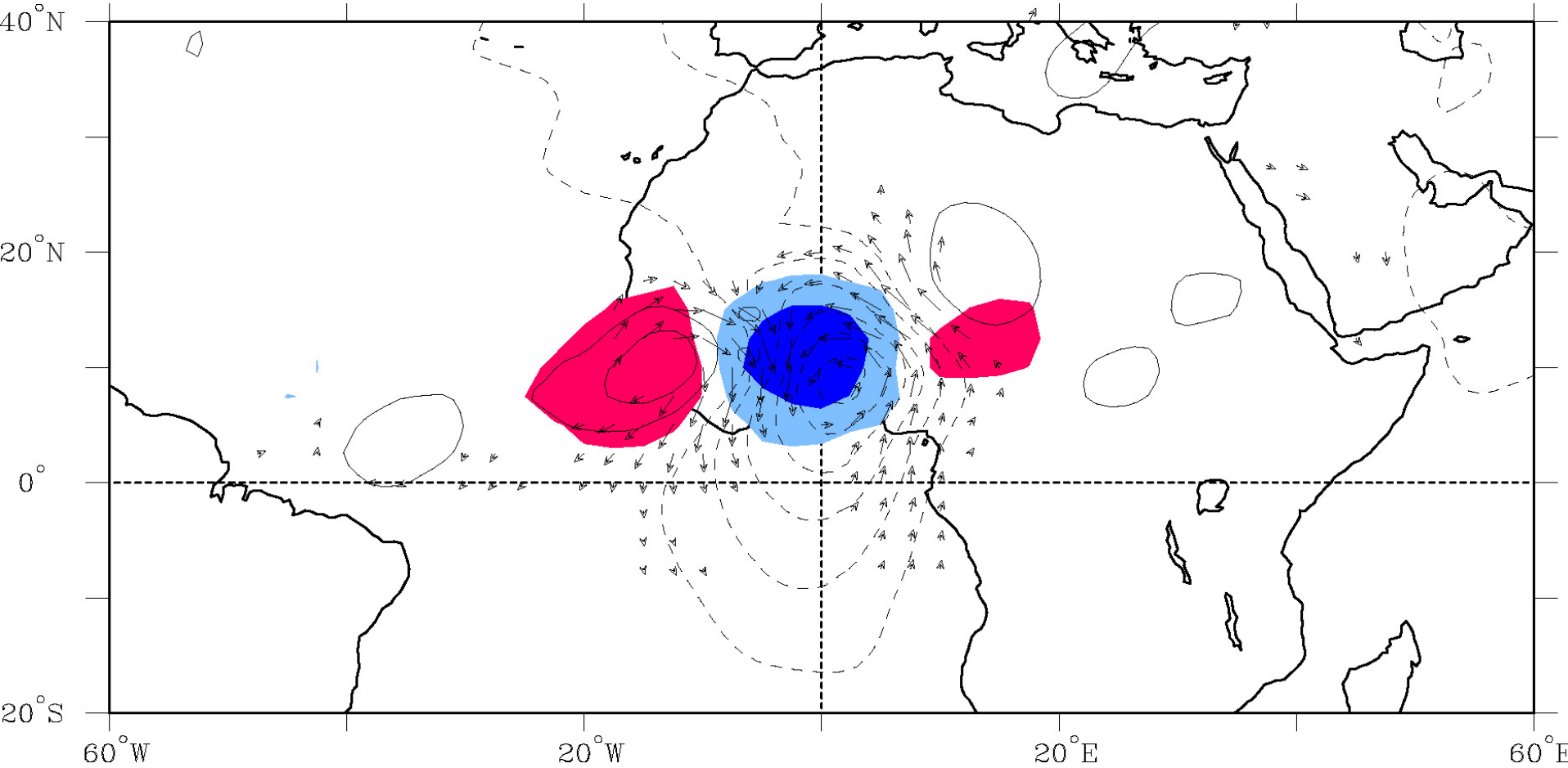


Day-1

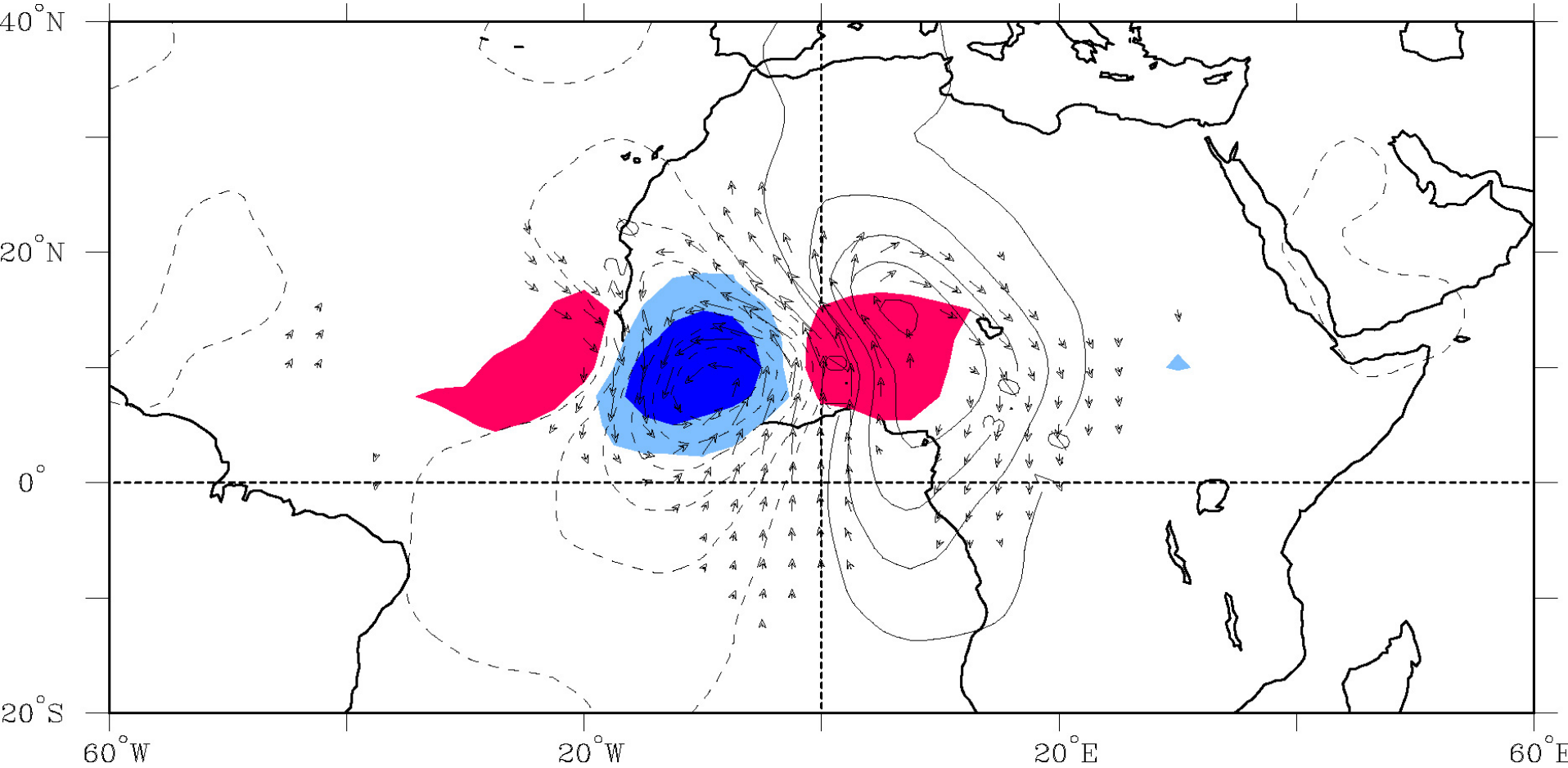
Streamfunction (contours 1 X 10^5 m^2 s^{-1})

Wind (vectors, largest around 2 m s^{-1})

OLR (shading starts at +/- 6 W s^{-2}), negative blue

Kiladis, Thorncroft, Hall (2006)

OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m^2) at 10°N, 10°W for June-September 1979-1993



Day 0

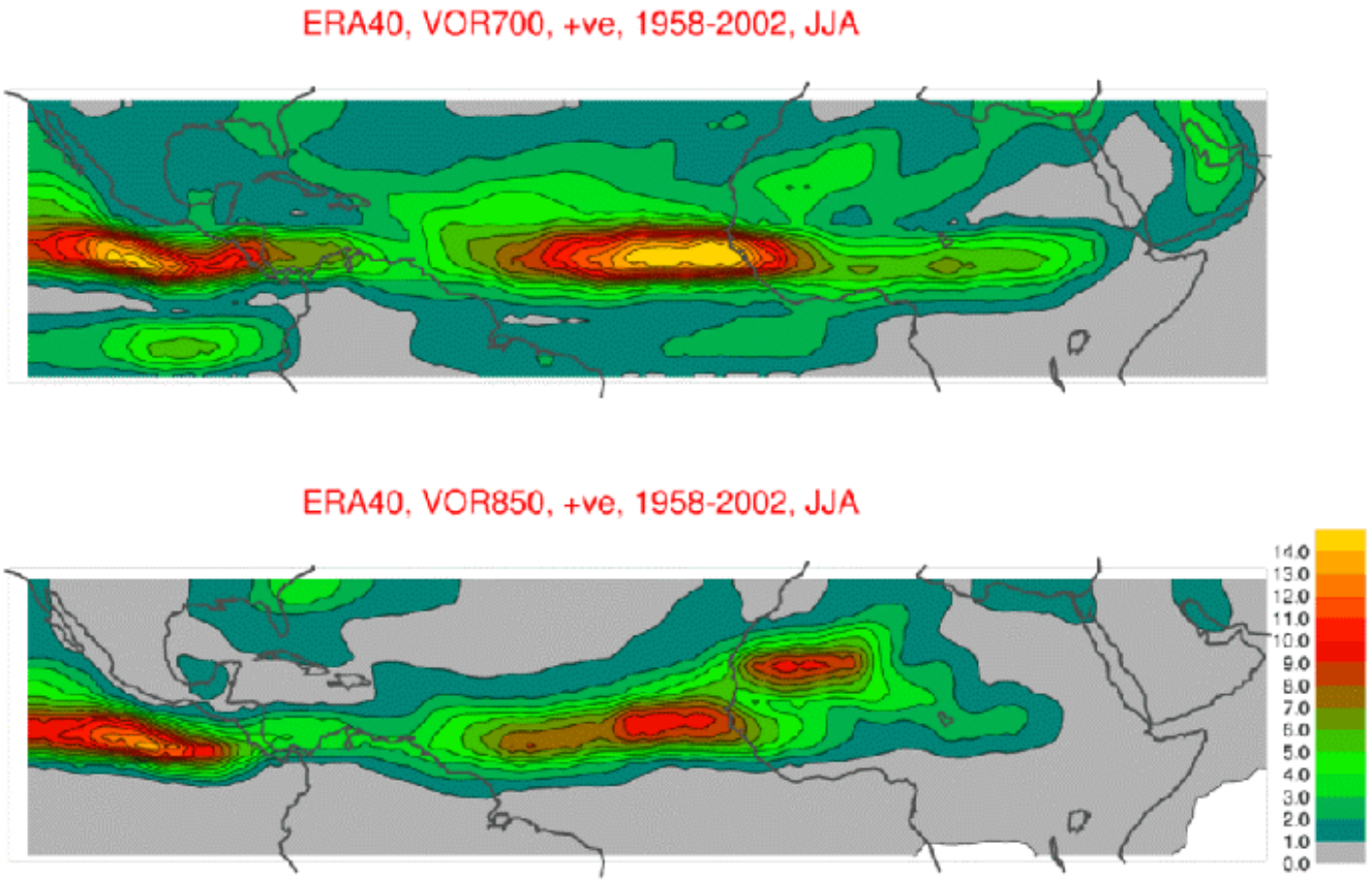
Streamfunction (contours 1 X 10^5 m^2 s^{-1})

Wind (vectors, largest around 2 m s^{-1})

OLR (shading starts at +/- 6 W s^{-2}), negative blue

Kiladis, Thorncroft, Hall (2006)

AEW Storm Tracks



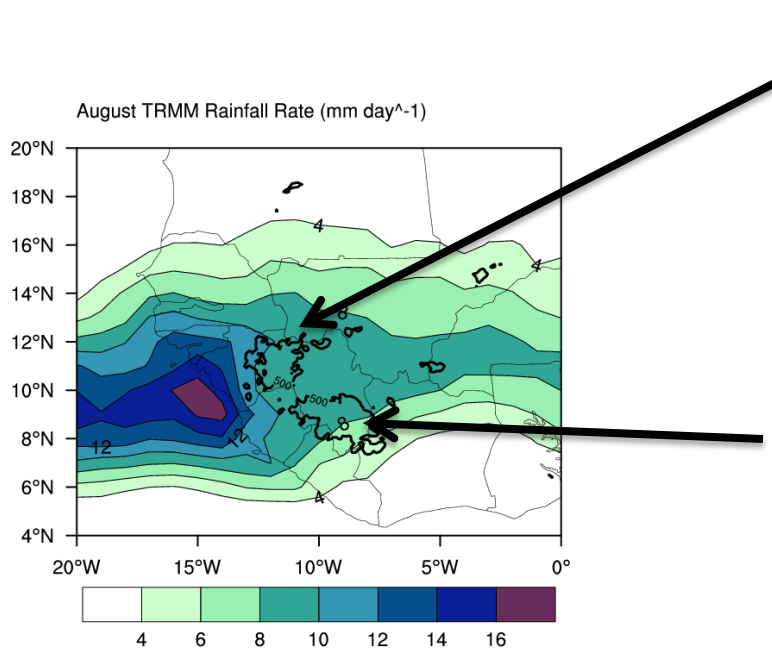
Thorncroft and Hodges (2001)

Importance of Guinea Highlands

• Marked transition takes place close to Guinea Highlands and Coastal region

•AEWs are often invigorated as they pass these regions – especially at low-levels

•May influence tropical cyclogenesis probabilities



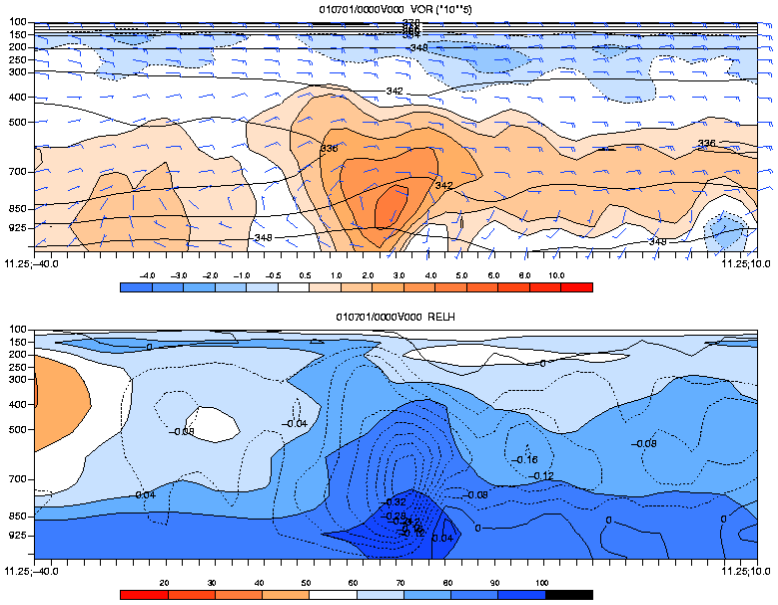
Fouta Djallon Highlands ~914m

The Nambia Range ~460m

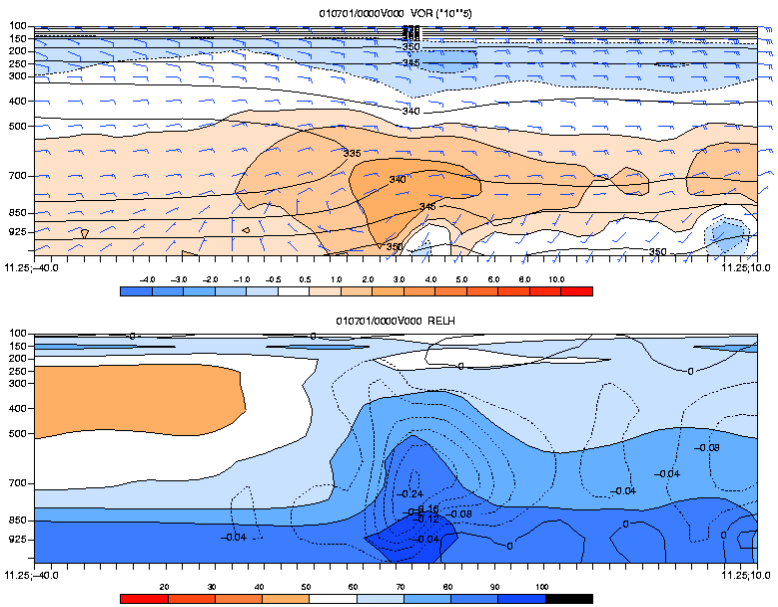
Importance of Guinea Highlands

Composites of East Atlantic Developing and Non-Developing AEWs (1979-2001)

Developing (33)



Non-Developing (512)



Hopsch , Thorncroft and Tyle 2009

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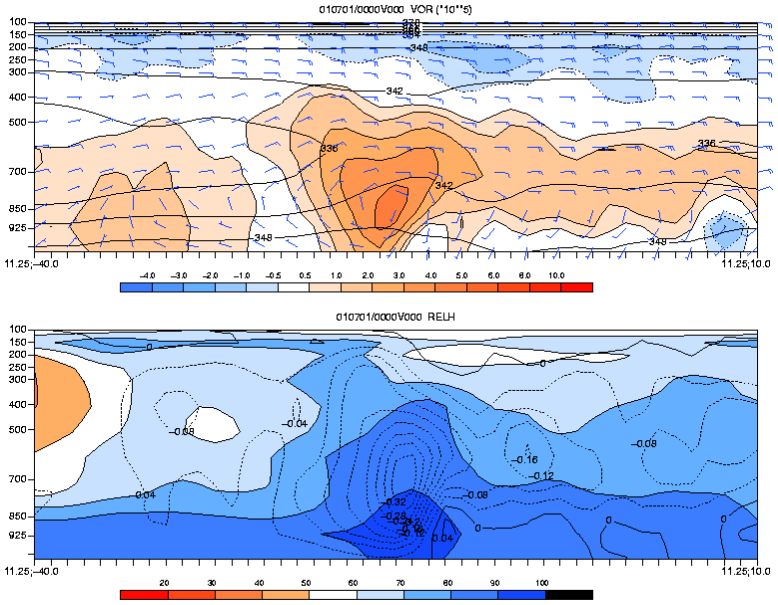
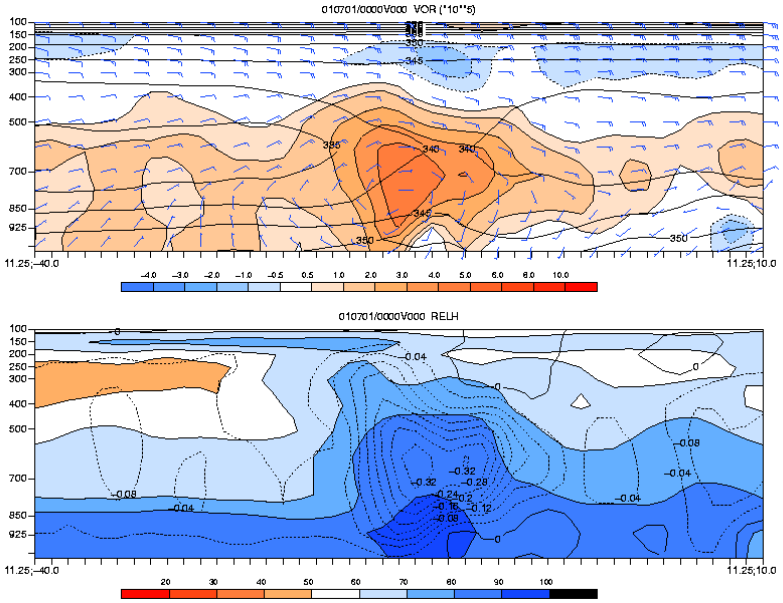
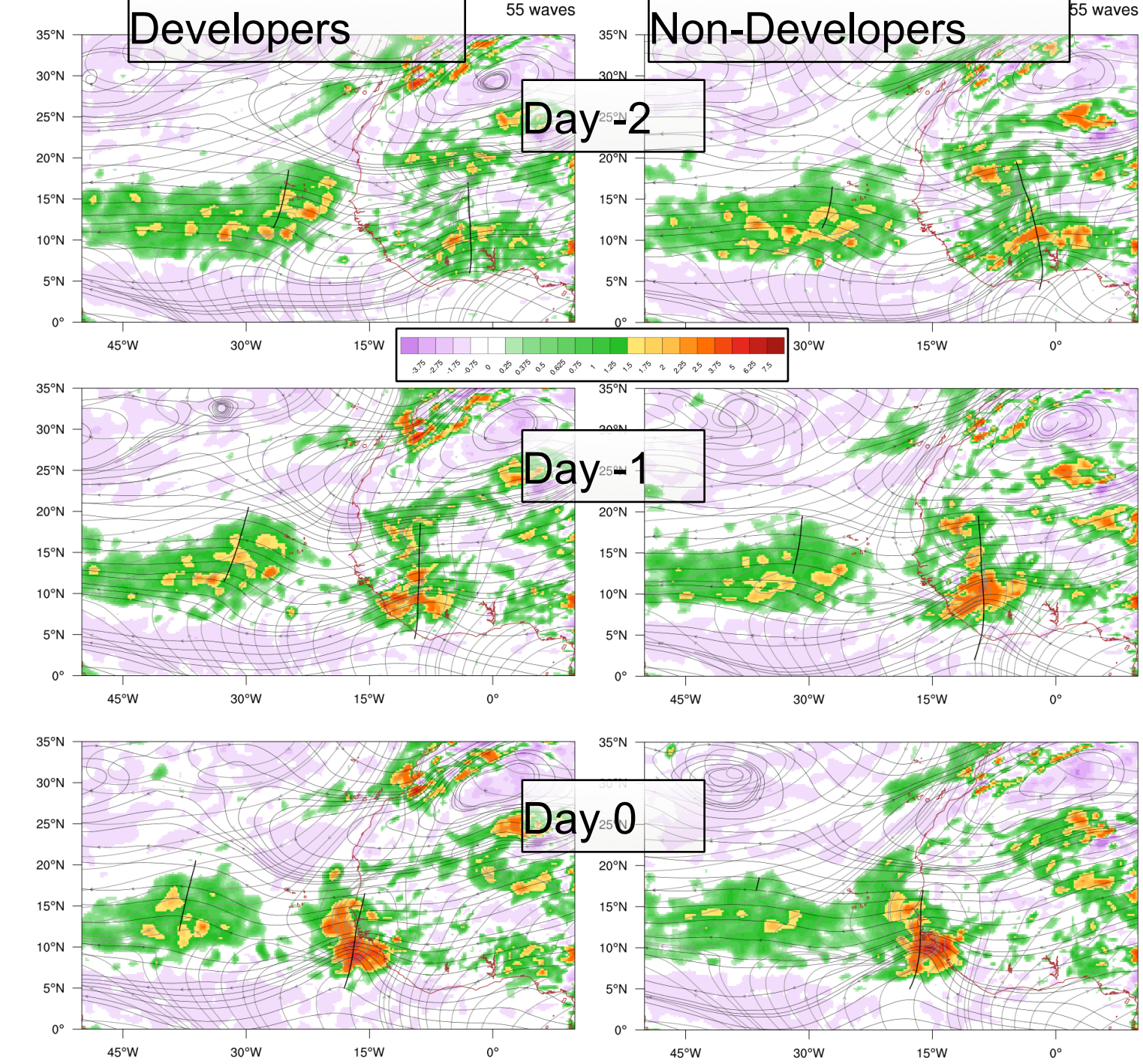


Non-Developing (33 most intense)



Hopsch , Thorncroft and Tyle 2009



850hPa Rel. Vort. [$10^{-5}s^{-1}$]

925hPa Streamlines (Grey)

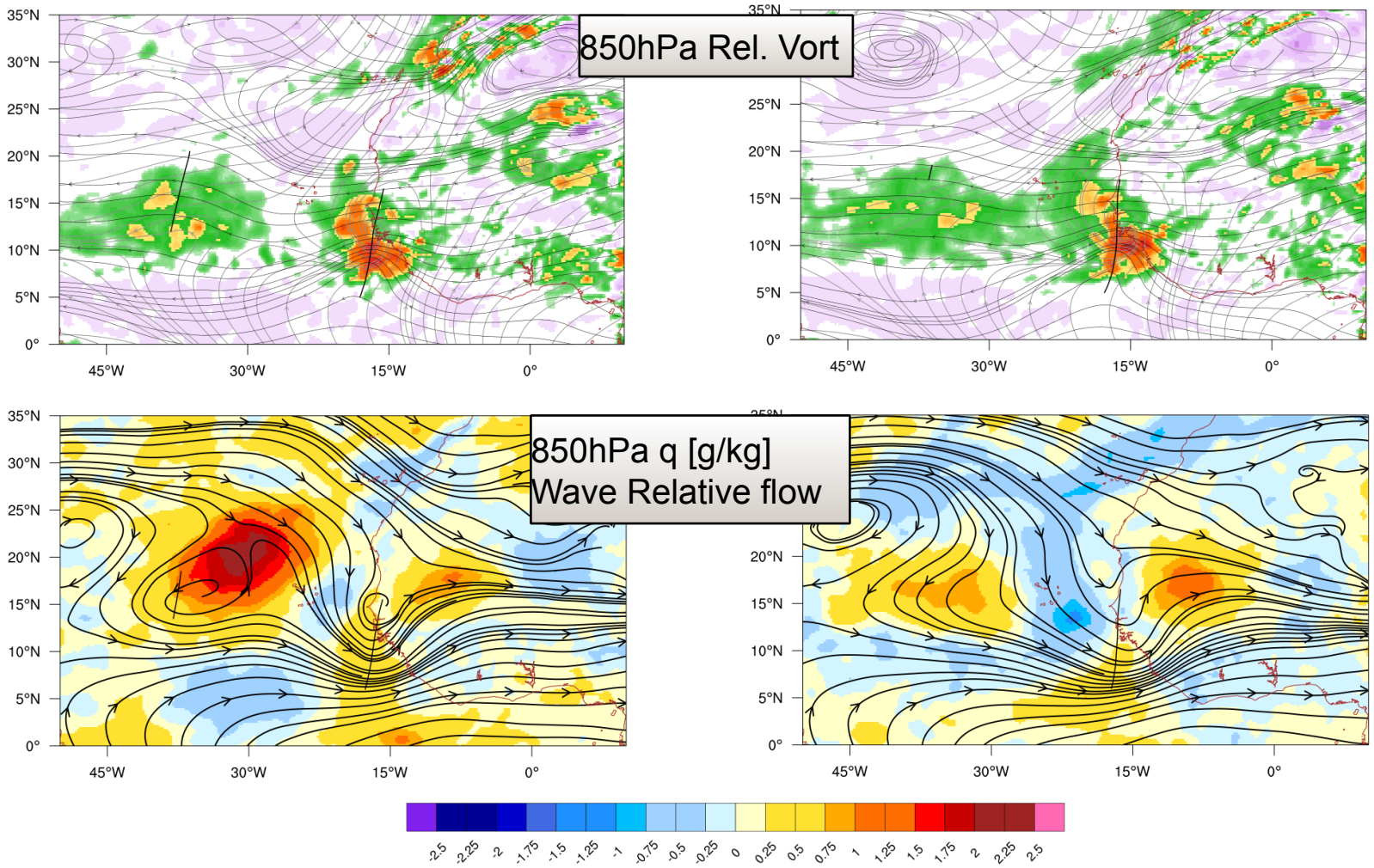
700hPa Streamlines (Black)

Objective Mean Trough Locations (Thick Black Contours)

Brammer and Thorncroft (2014)

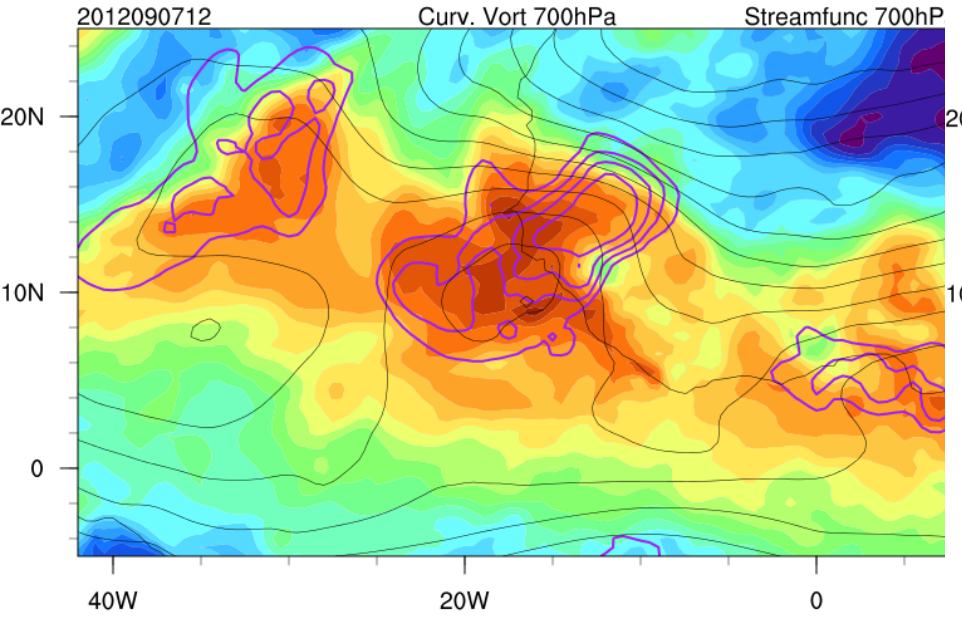
Day 0

Developing Non-developing

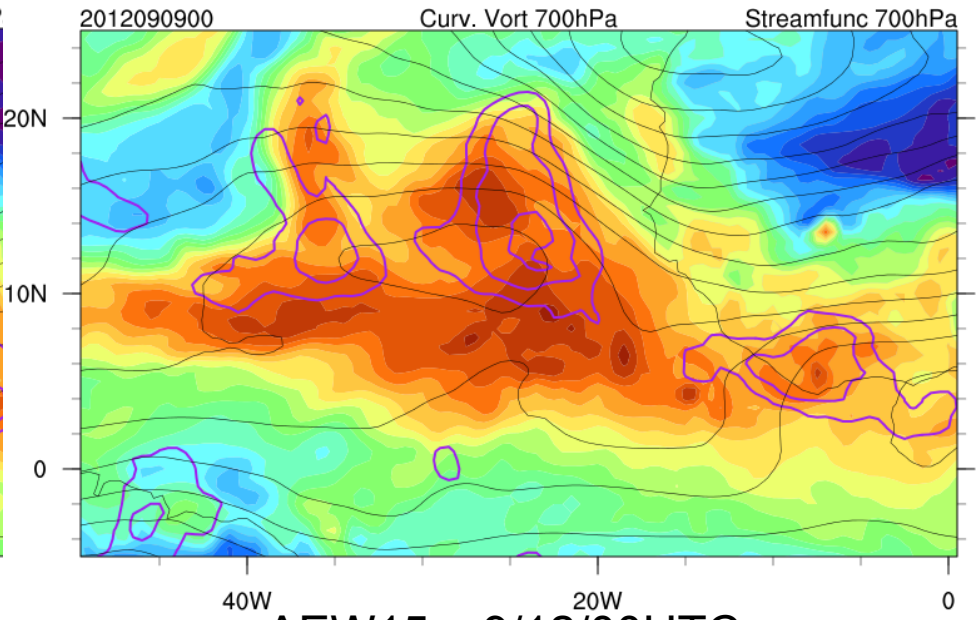


Brammer and Thorncroft (2014)

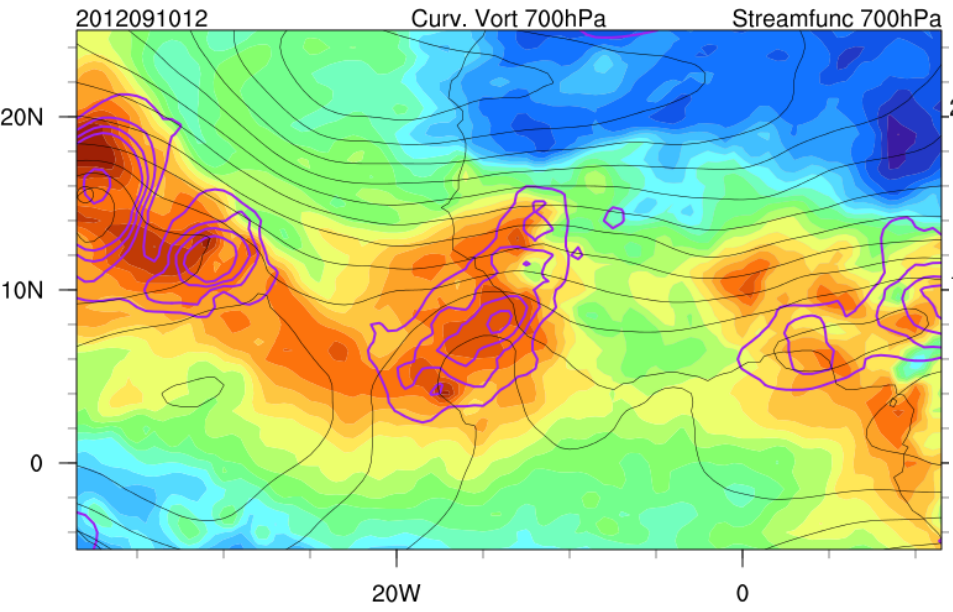
Nadine – 9/7/12UTC



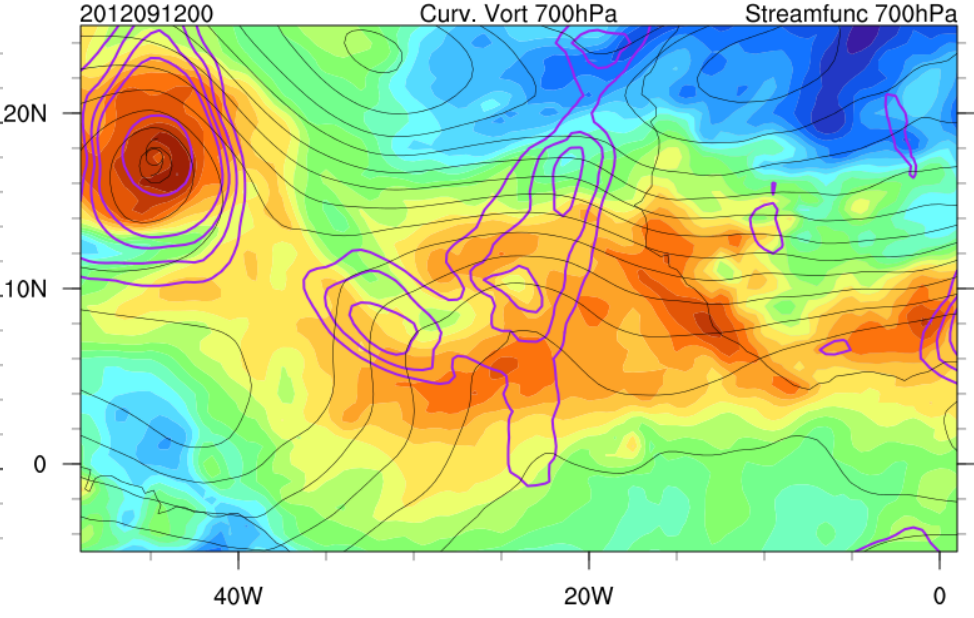
Nadine – 9/9/00UTC

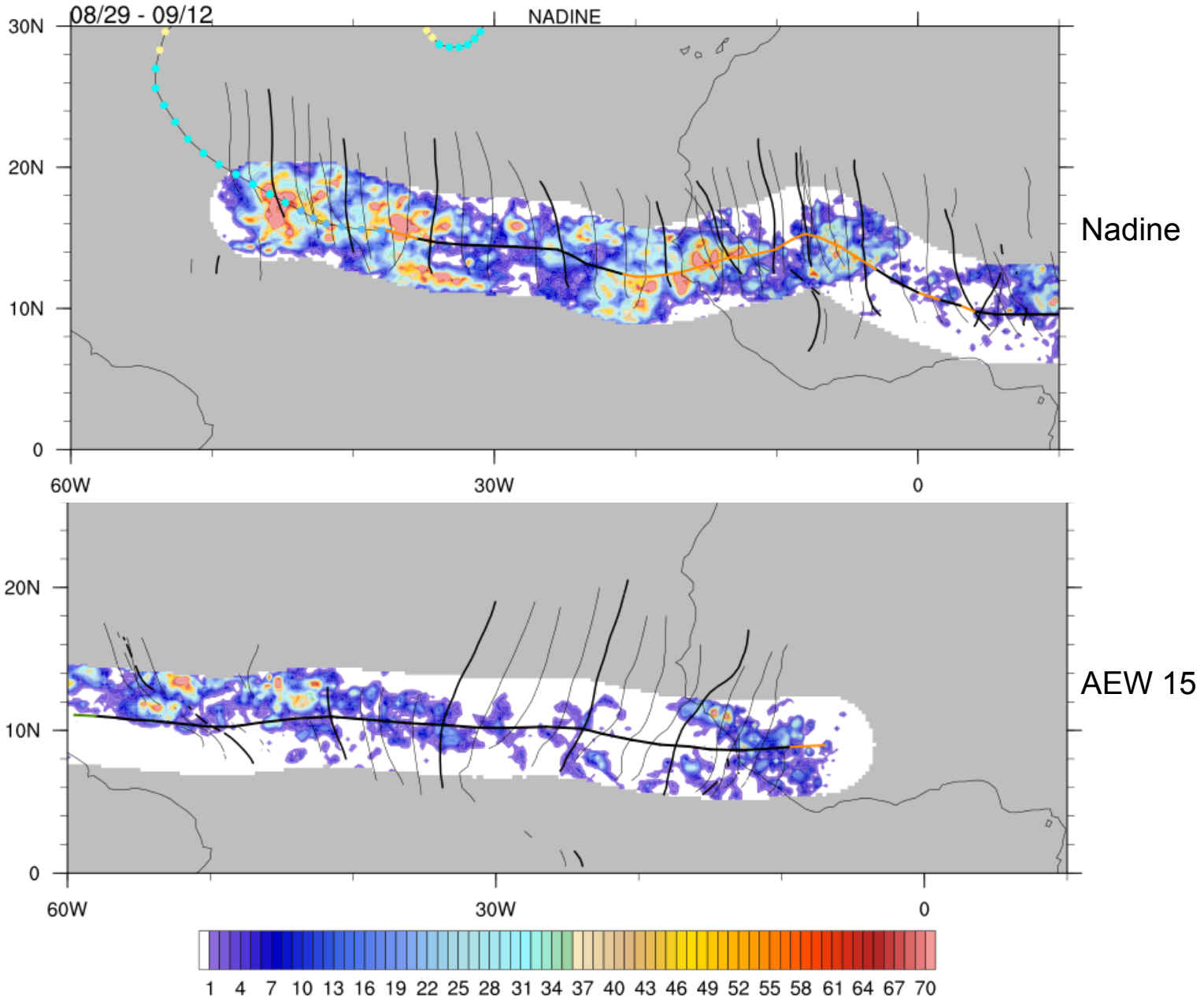


AEW15 – 9/10/12UTC



AEW15 – 9/12/00UTC




08/29 - 09/12
NADINE
30N
20N
10N
0
60W
30W
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Nadine
20N
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30W
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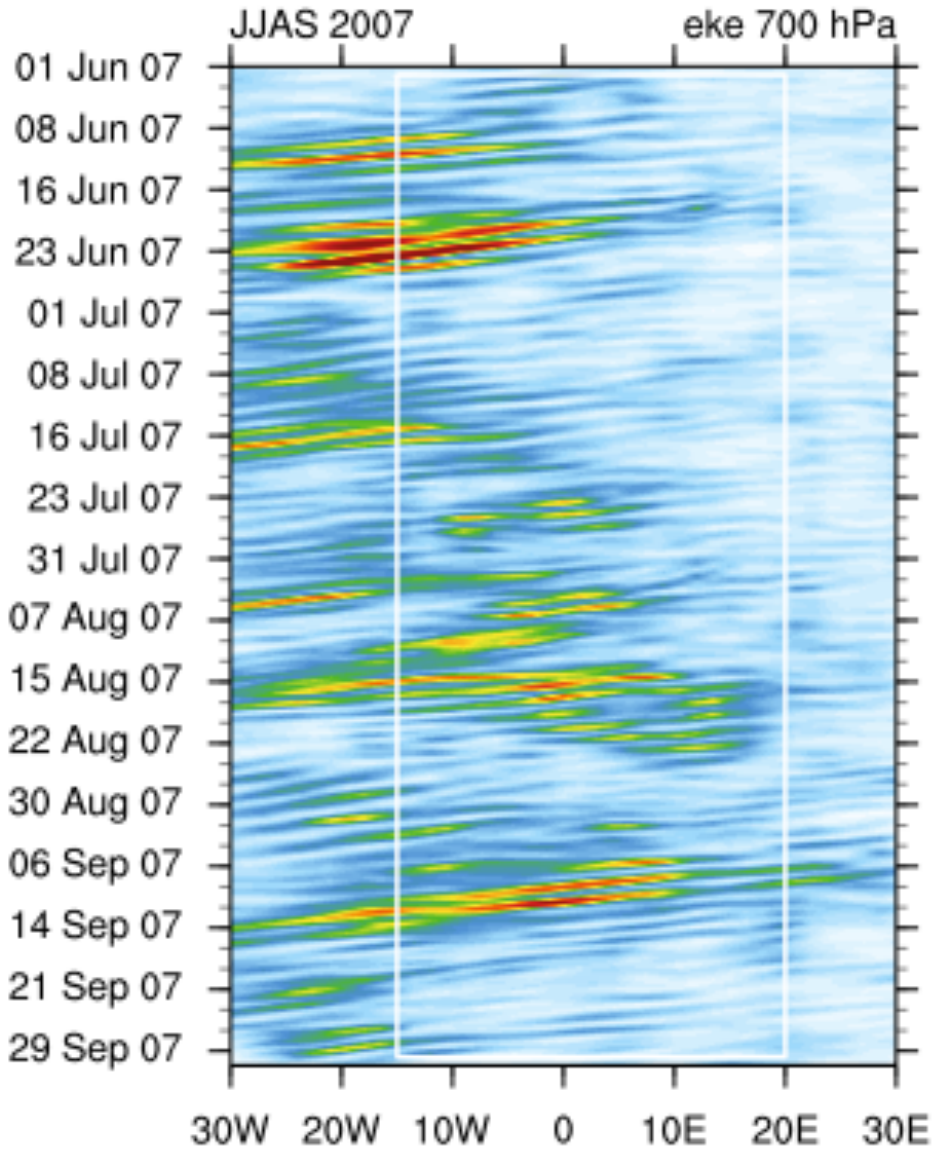
AEW 15
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70

3. Variability in African Easterly Wave Activity



3. Variability in African Easterly Wave Activity

Approach taken here is to consider impact of known phenomena on AEW-activity.

MJO has a coherent relationship with AEW-activity (measured by EKE):
Ventrice, Thorncroft and Roundy, 2012
Alaka and Maloney, 2013

Convectively Coupled Kelvin Waves can impact convection and AEWs:
Ventrice, Thorncroft and Roundy,2012
Ventrice and Thorncroft, 2013

Variability in African Easterly Wave Activity - MJO

OLR

RMM Phase 1

RMM Phase 2

RMM Phase 3

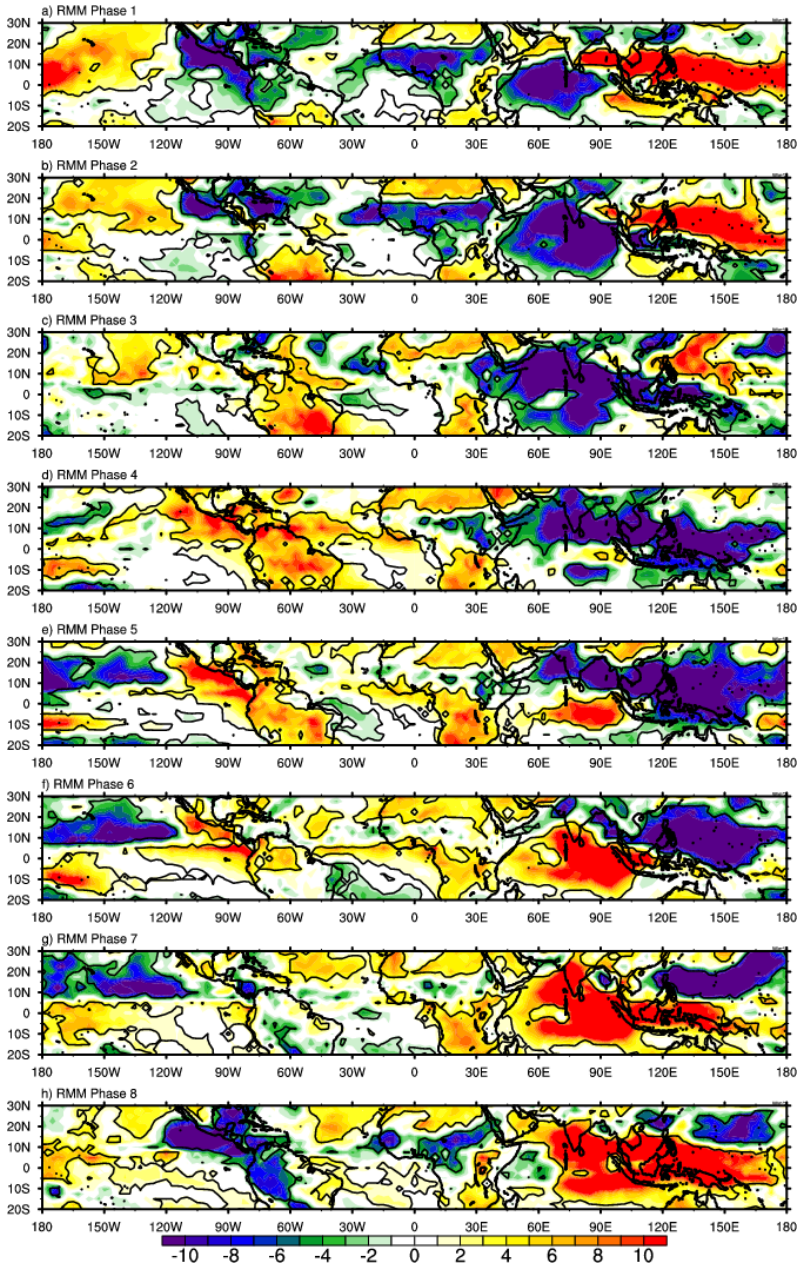
RMM Phase 4

RMM Phase 5

RMM Phase 6

RMM Phase 7

RMM Phase 8



Ventrice et al, 2012

Variability in African Easterly Wave Activity - MJO

OLR

2-10d filtered 700 hPa EKE

RMM Phase 1

RMM Phase 2

RMM Phase 3

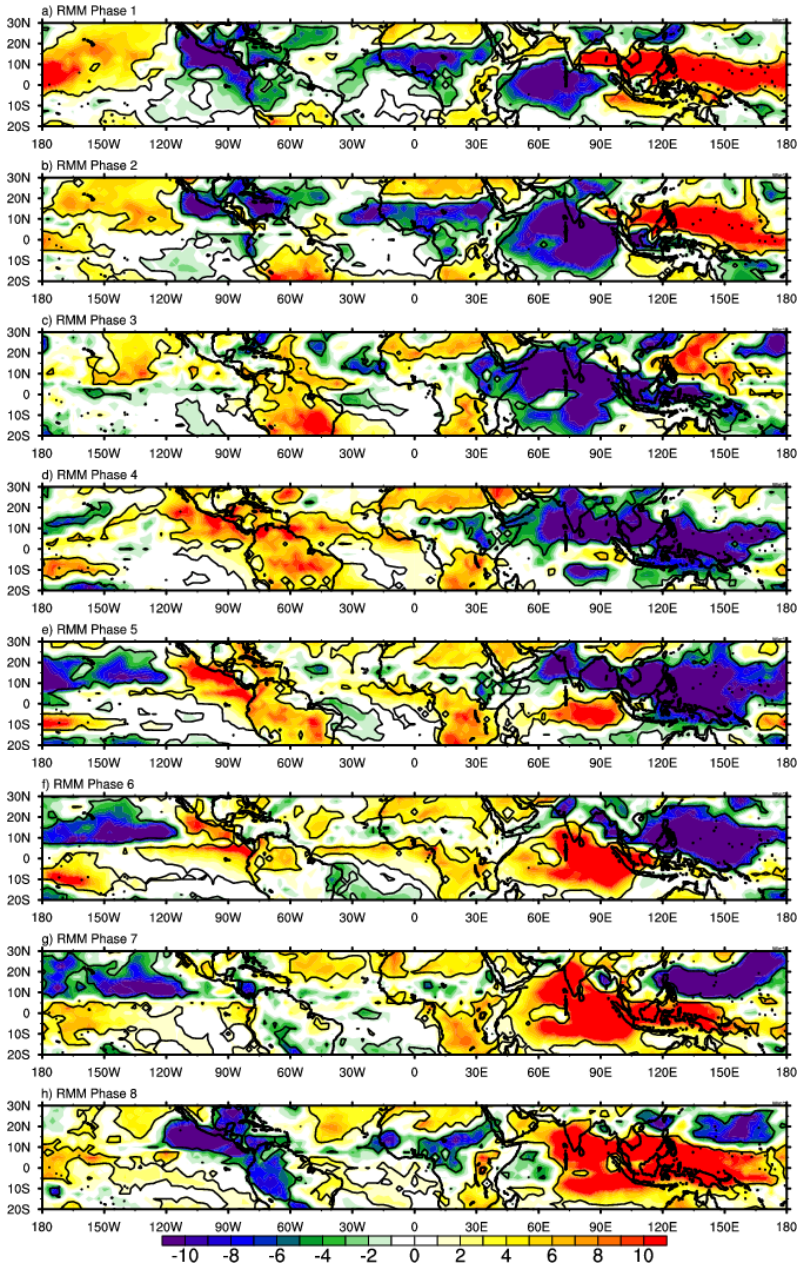
RMM Phase 4

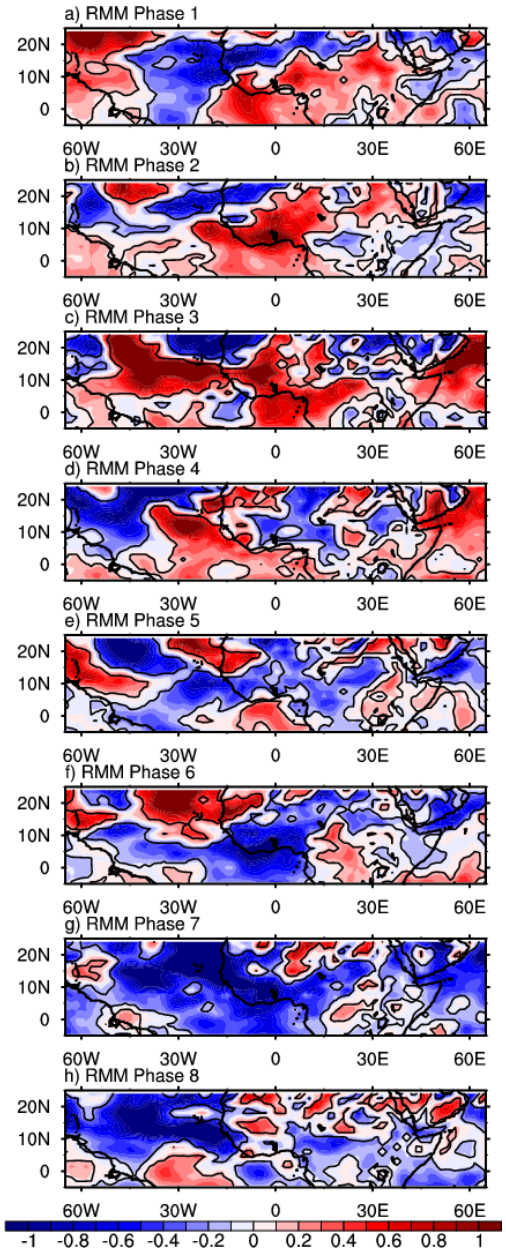
RMM Phase 5

RMM Phase 6

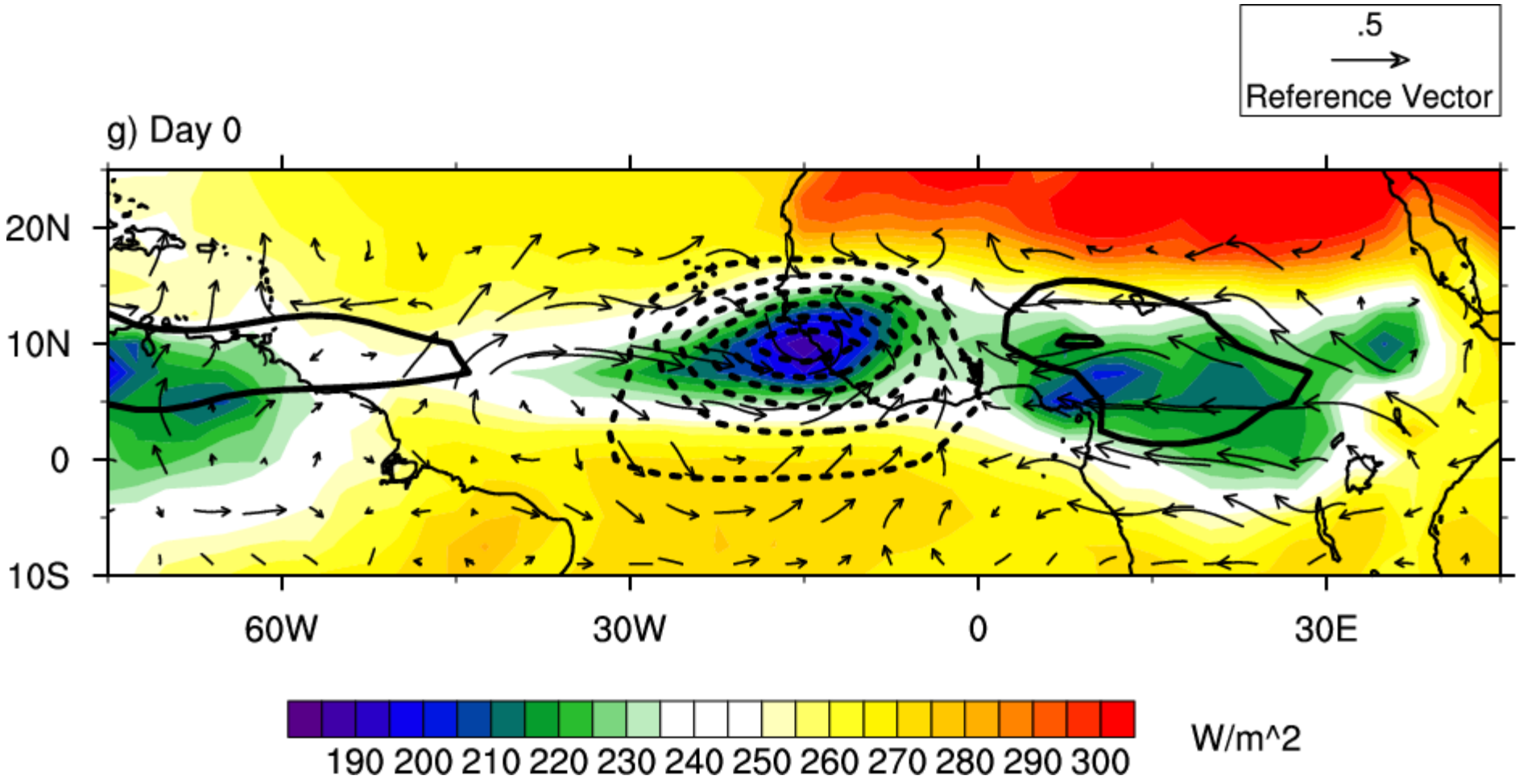
RMM Phase 7

RMM Phase 8





Unfiltered OLR, Kelvin-filtered OLR and 850hPa wind anomalies



Key:

- **Unfiltered total OLR field (Shaded)**
- **Kelvin filtered OLR (Contours) are contoured if statistically different than zero at the 95% level**
- **Positive (Negative) Kelvin filtered OLR anomalies 850 hPa wind anomalies (Vectors)**

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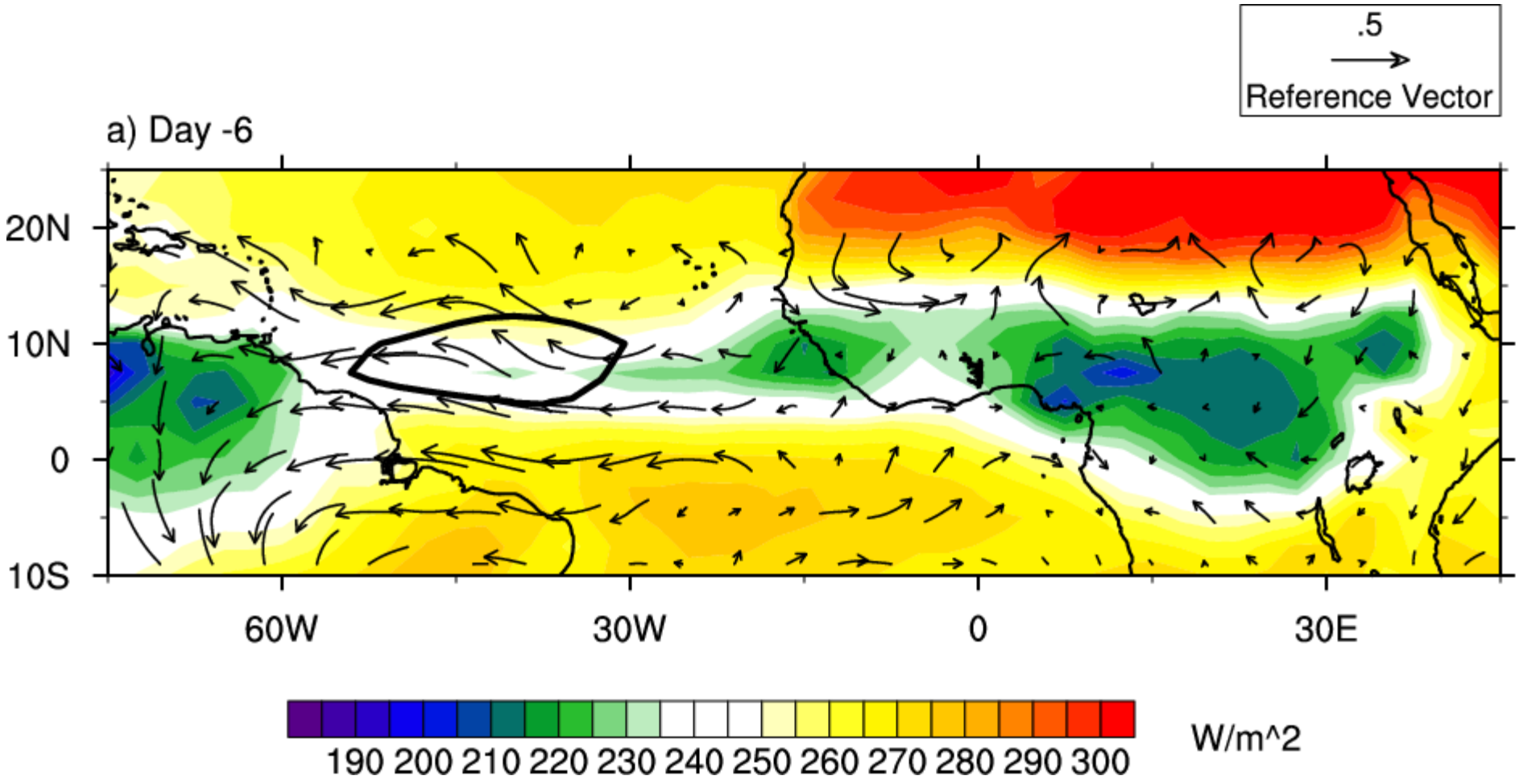

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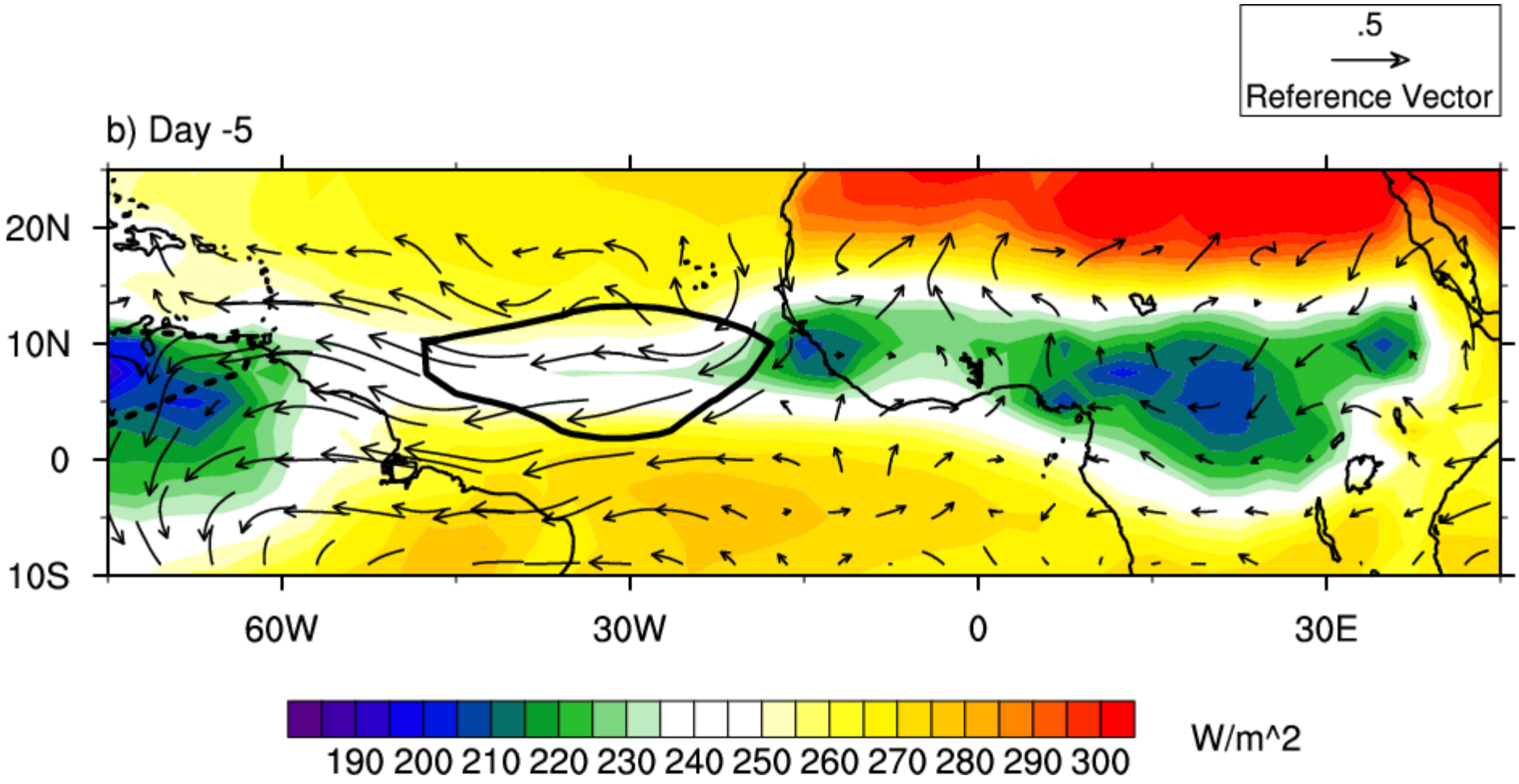

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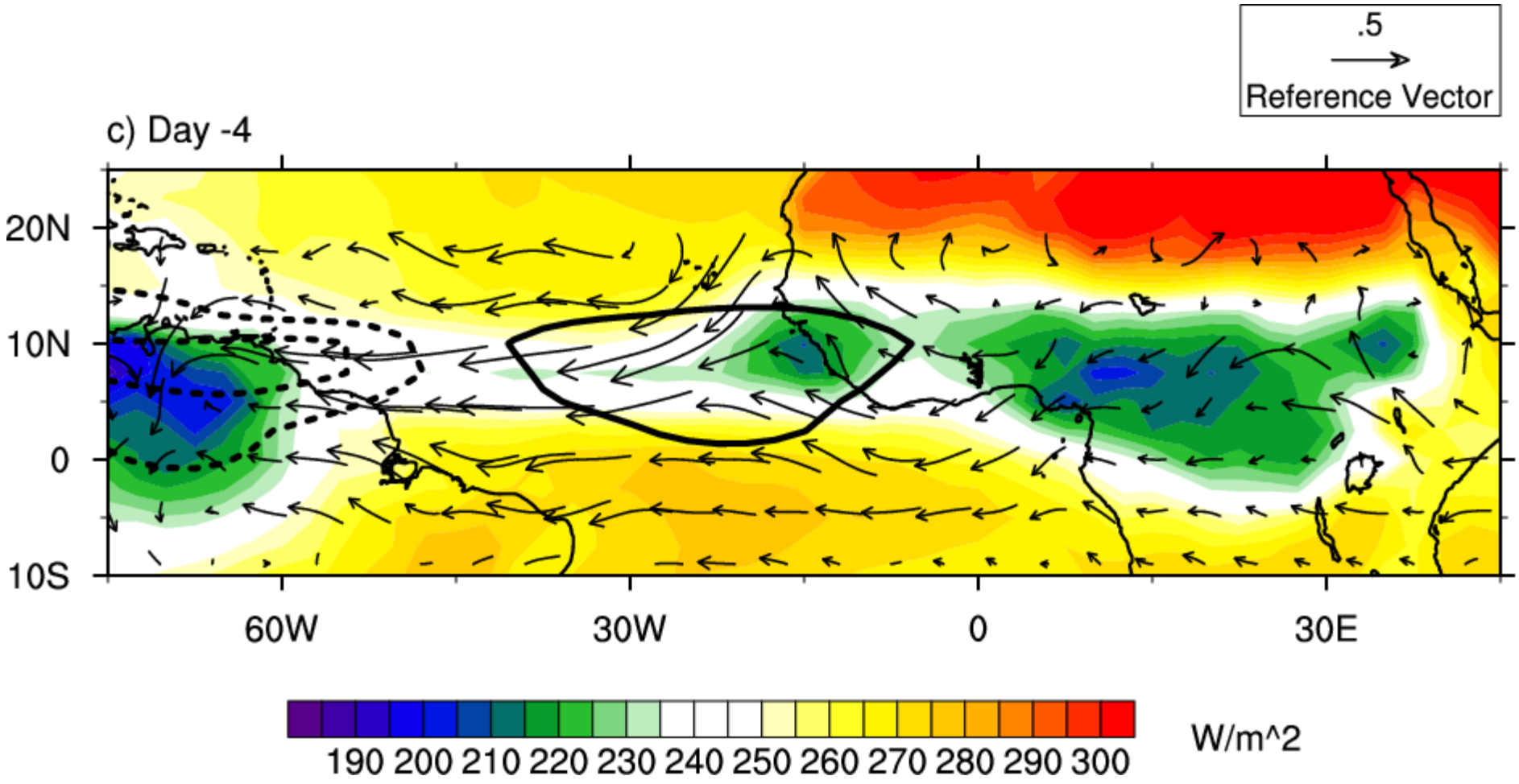

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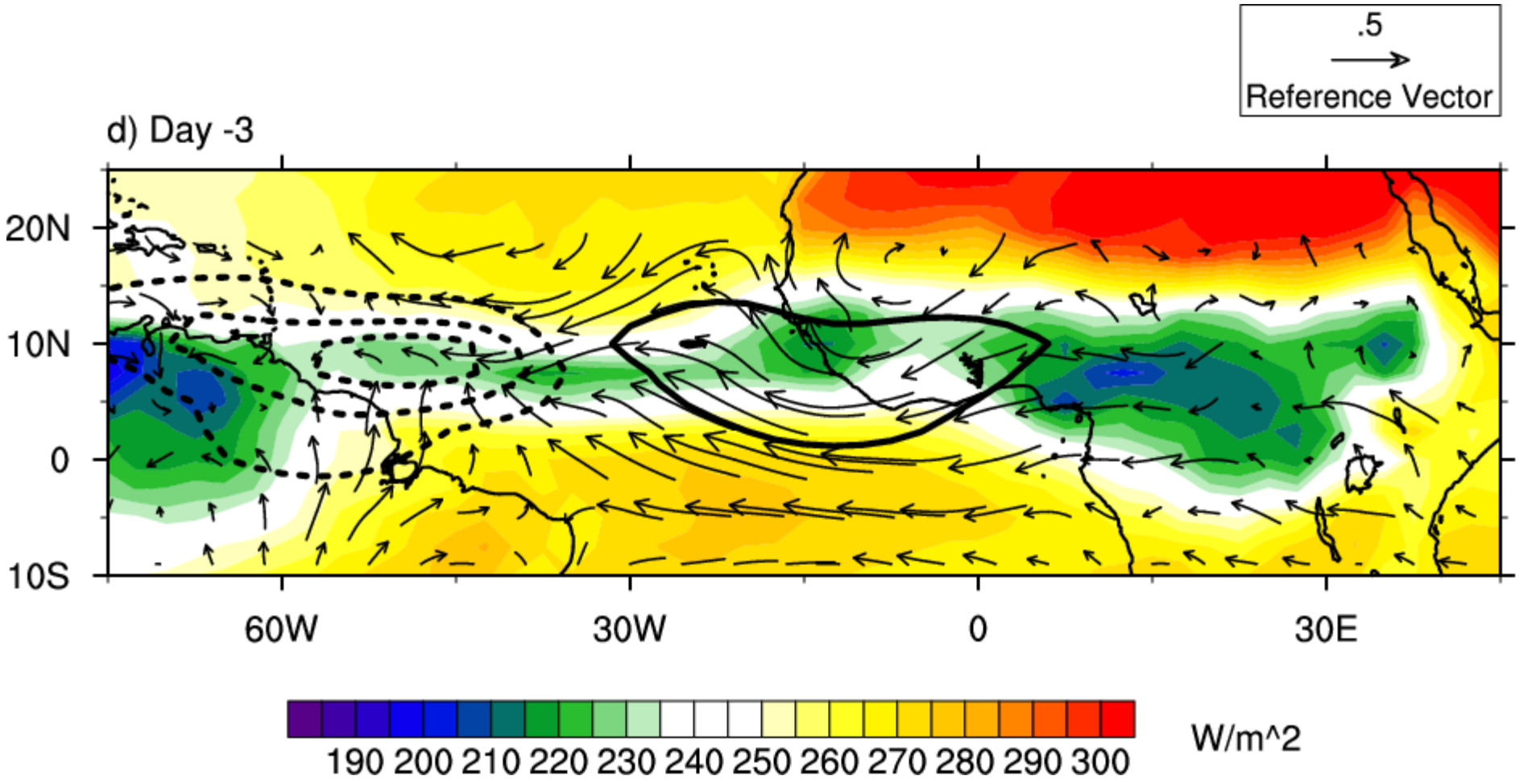

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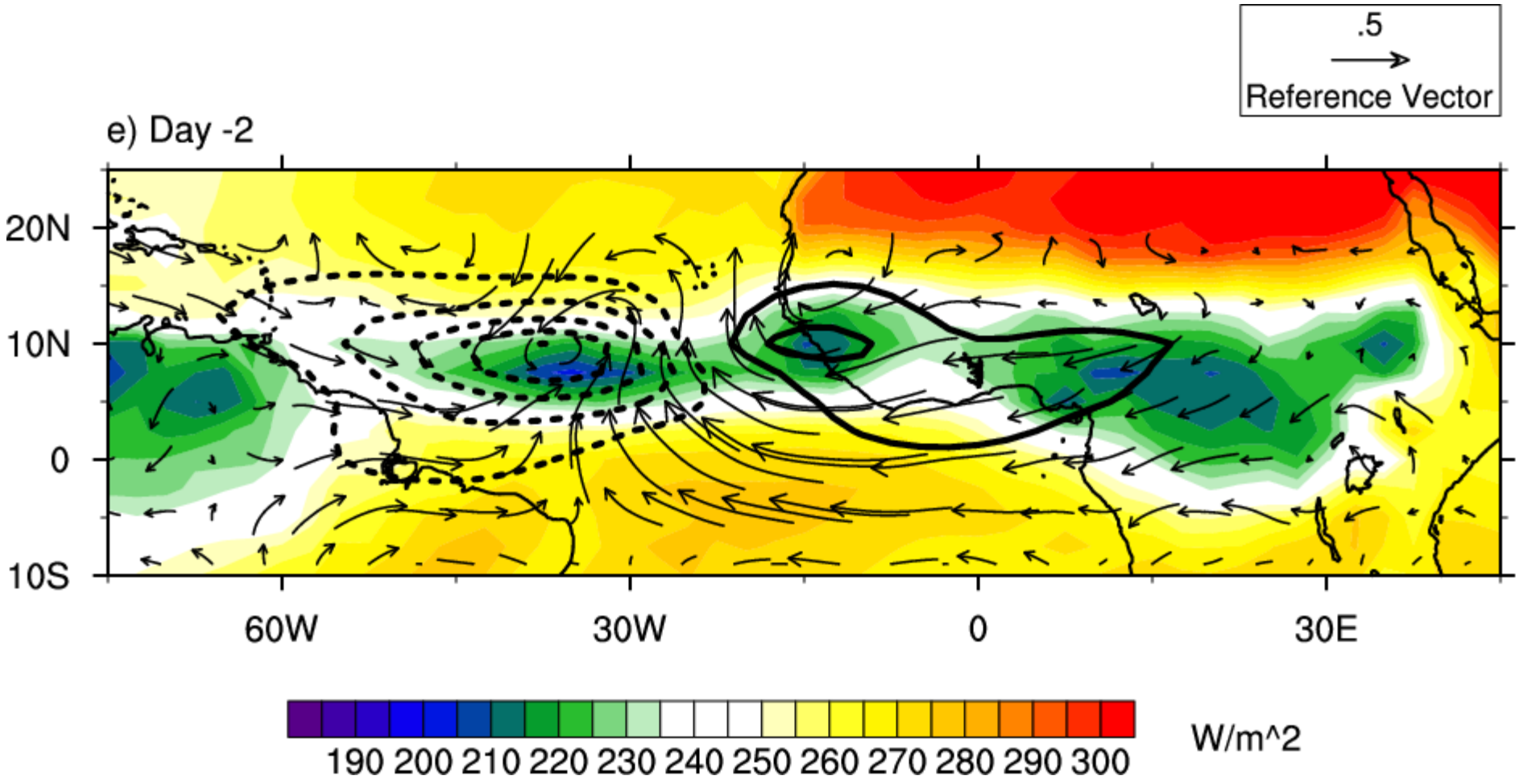

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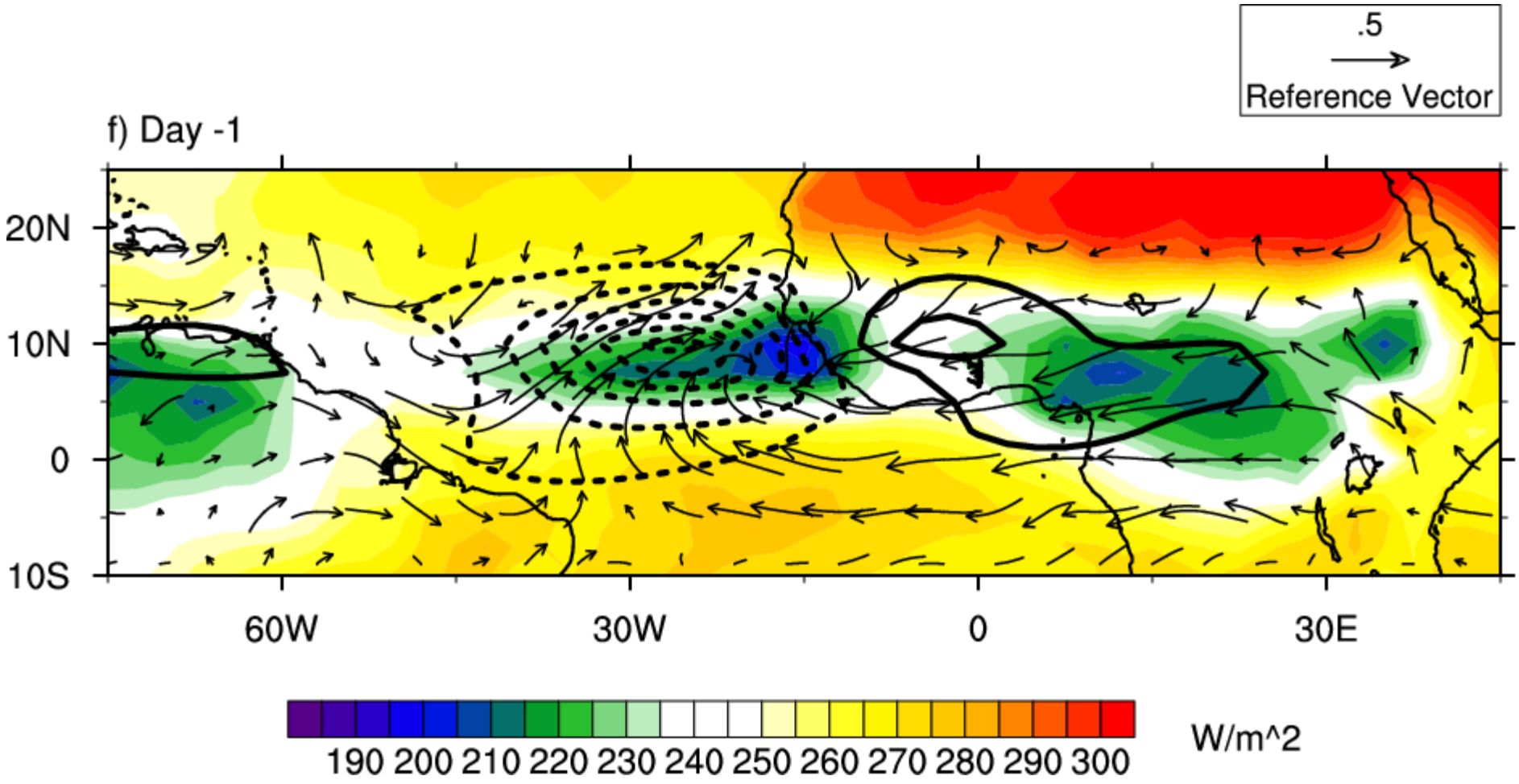

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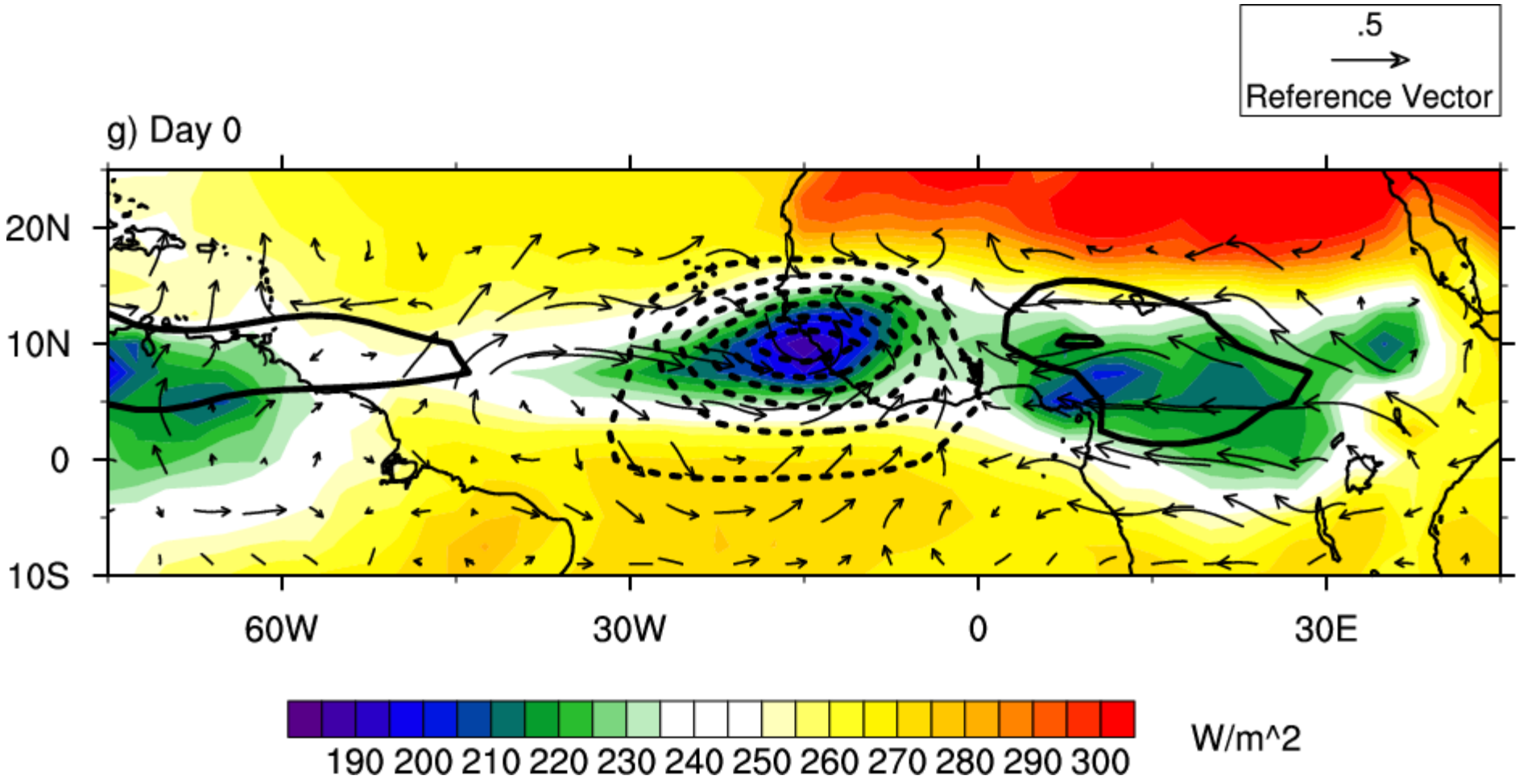

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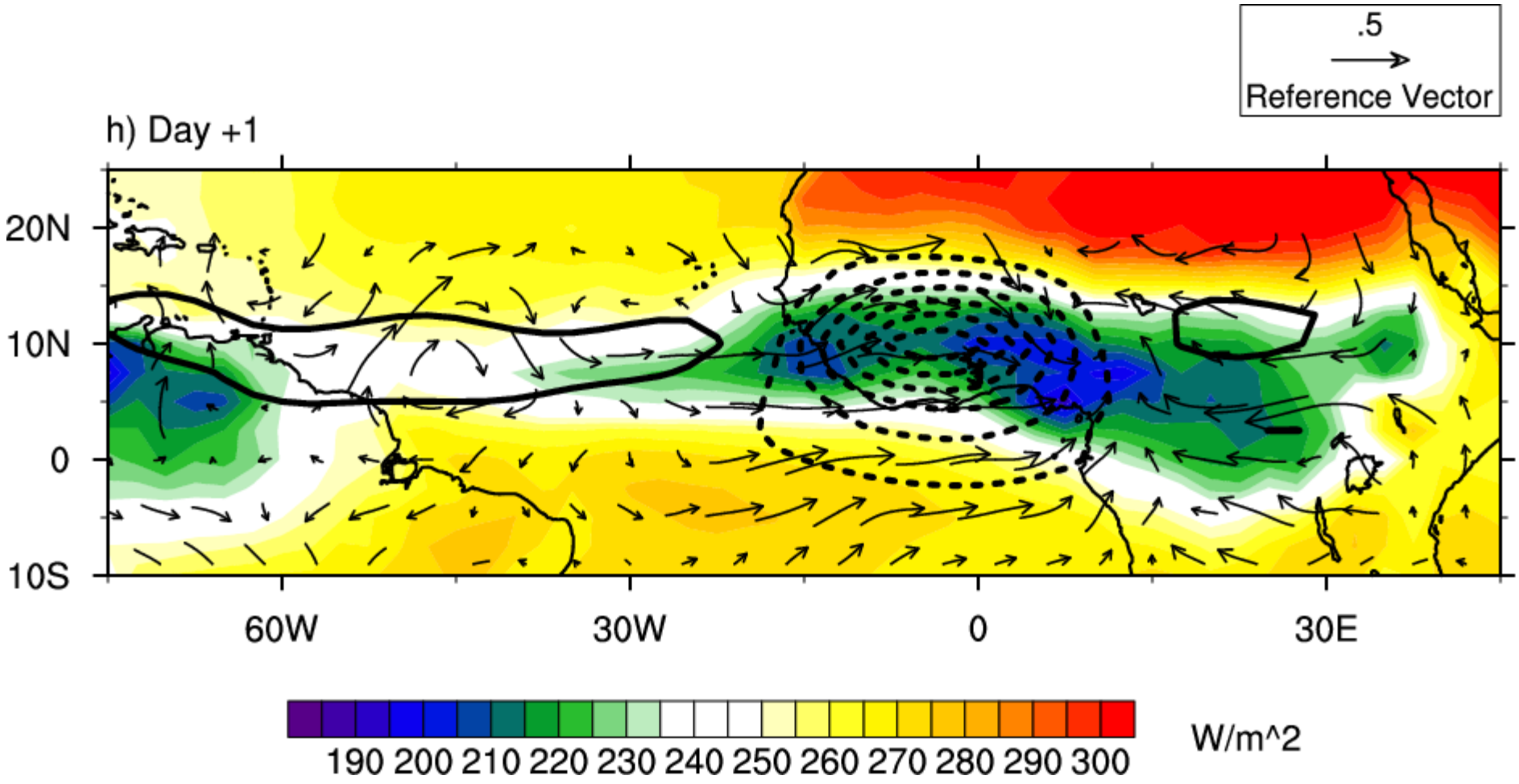

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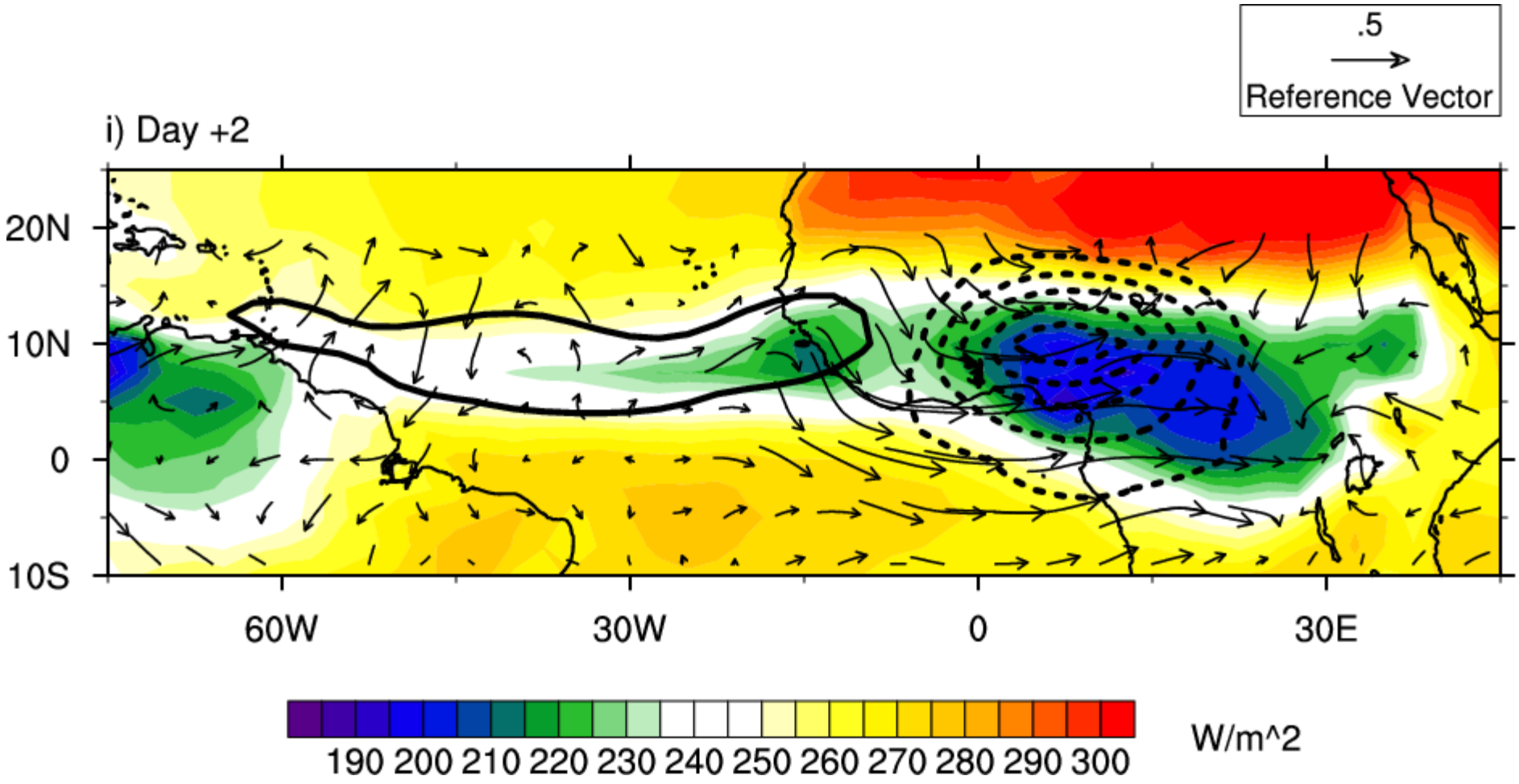

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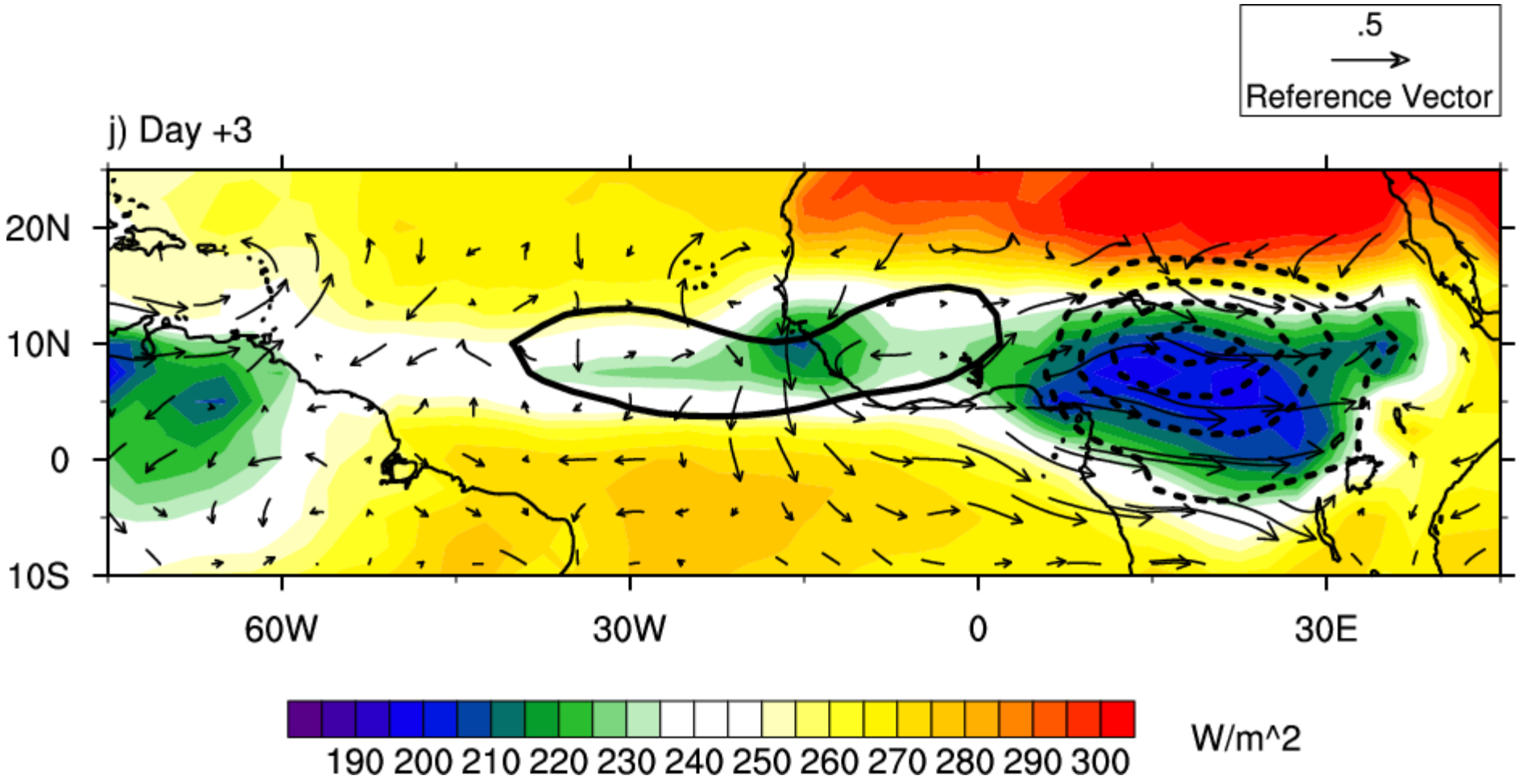

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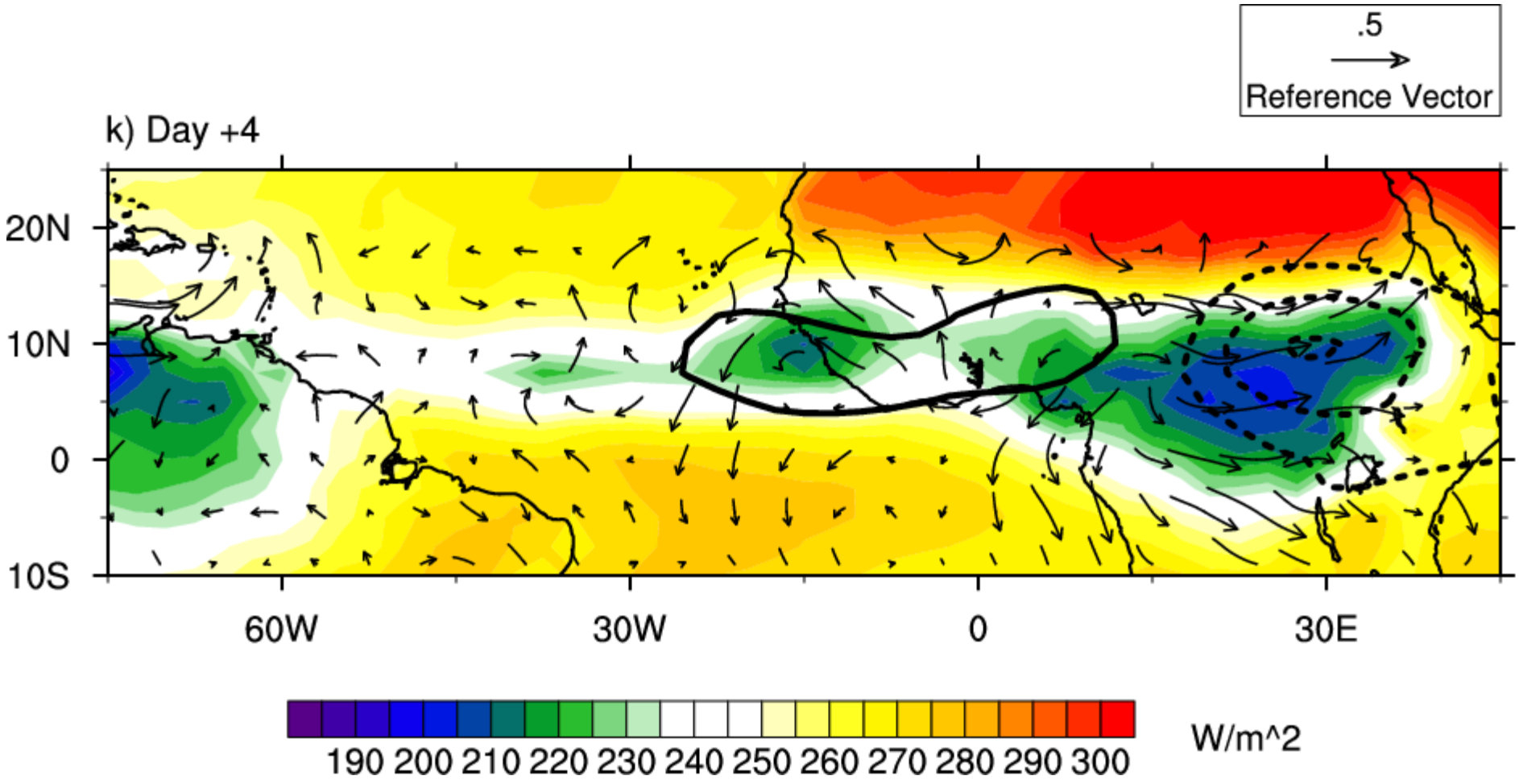
- **Positive (Negative) Kelvin filtered OLR anomalies 850 hPa wind anomalies (Vectors)**

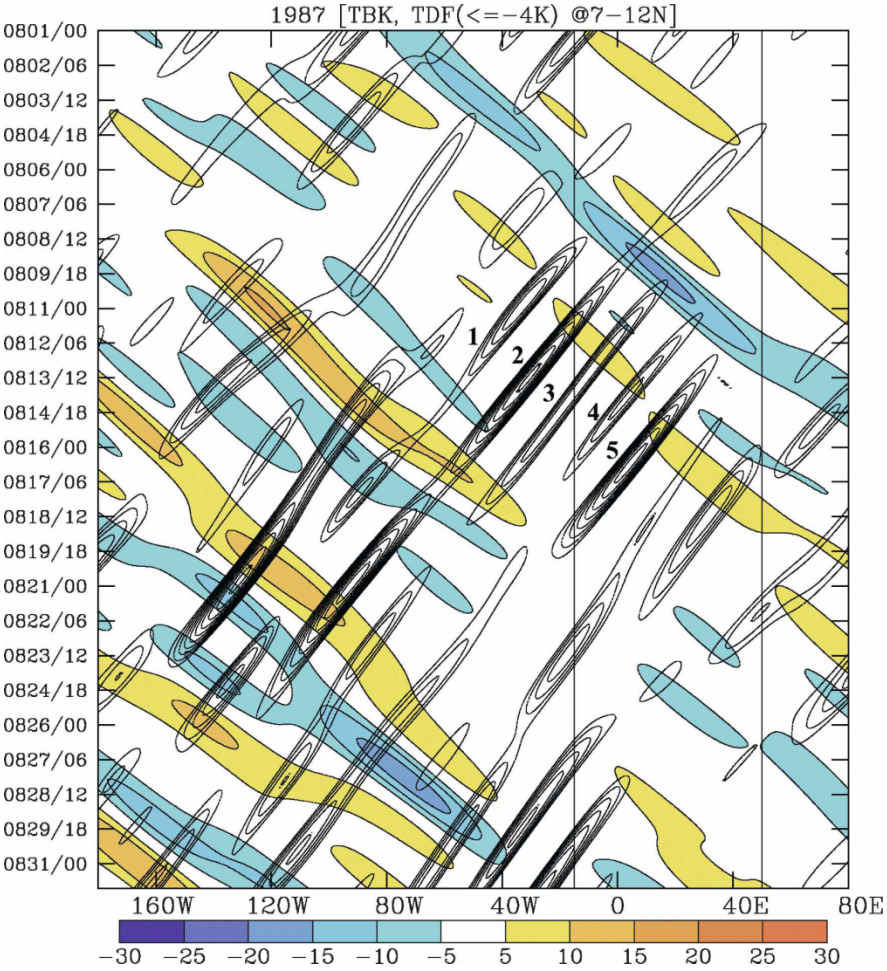
Unfiltered OLR, Kelvin-filtered OLR and 850hPa wind anomalies



Key:

- **Unfiltered total OLR field (Shaded)**
- **Kelvin filtered OLR (Contours) are contoured if statistically different than zero at the 95% level**
- **Positive (Negative) Kelvin filtered OLR anomalies 850 hPa wind anomalies (Vectors)**

Variability in African Easterly Wave Activity - CCKWs



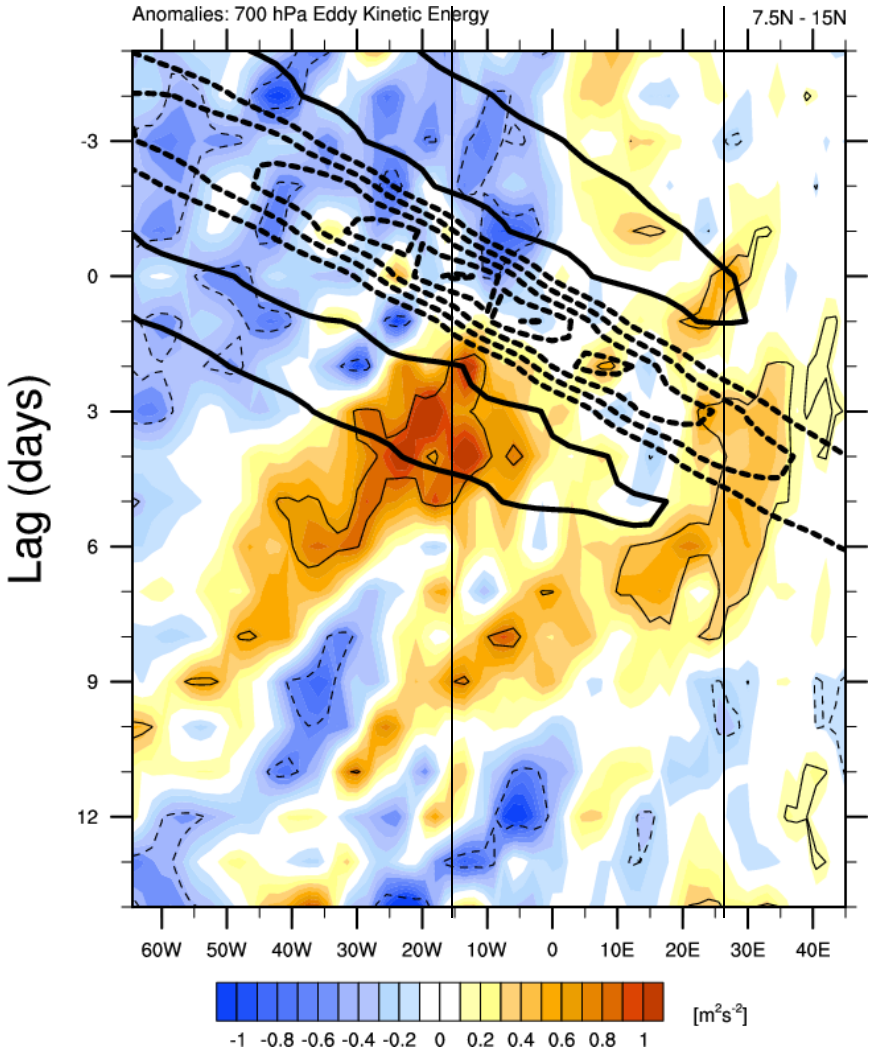
from Mekonnen et al. 2008

Shading: Kelvin filtered brightness temperature (Tb) anomalies

Contours: Tropical Depression type wave filtered Tb anomalies

- AEW wave train develops after the passage of convectively active phase of a CCKW.
- AEWs initiate (or amplify) east of one another

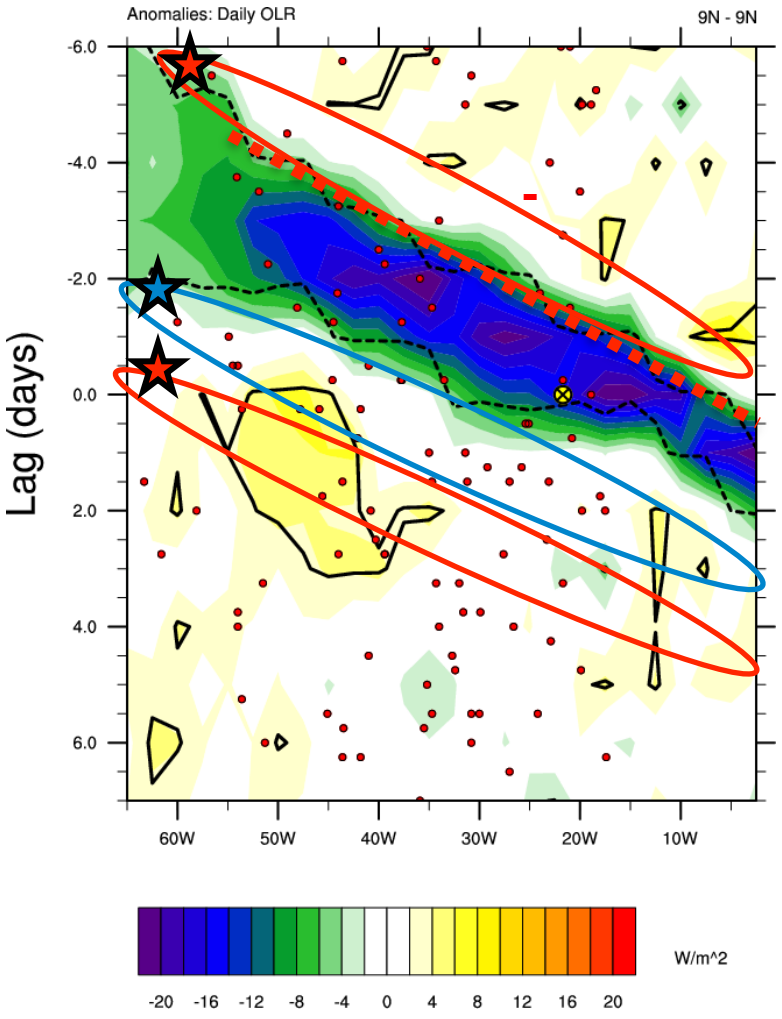
CCKW-AEW-activity Relationship



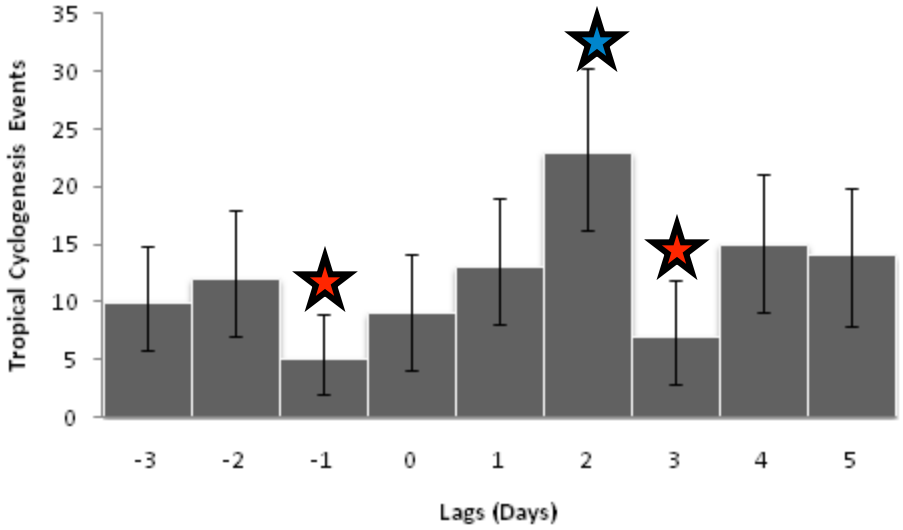
Shading: 700 hPa EKE anomalies (contoured if statistically different than zero at the 90% level)

Bold Black Contours: Kelvin filtered OLR anomalies (dashed if negative)

AEW-CCKW-TC Relationships



Tropical cyclogenesis relative to the Kelvin wave



Regional Variations in AEW Structure

- There are marked variations in AEW structures as they propagate between the African continent and the ocean.

- AEWs intensify and develop low level circulations as they pass the Guinea Highlands and coastal region.

- Variability in these processes likely impacts probability of tropical cyclogenesis.

- The most important differentiator between favorable AEWs that develop and those that do not is the presence (or not) of moist air at low-levels ahead of the AEW.

Final Comments

Variability in AEW Activity

- There is marked sub-seasonal variability in AEW activity.

- The MJO influences AEW-activity.

- This talk has highlighted the role of Convectively Coupled Kelvin Waves in generating such variability.

- CCKW-AEW interactions can influence the probability of rainfall over the African continent and tropical cyclogenesis in the tropical Atlantic.

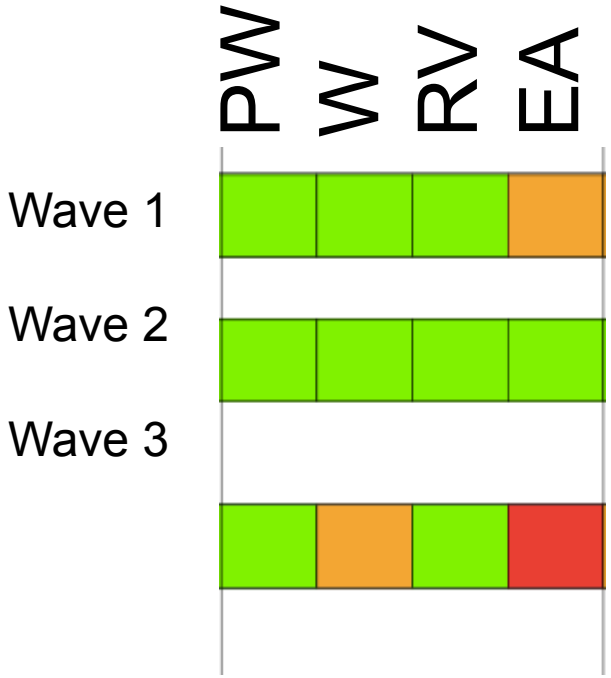
Monitoring AEW-quality in Real-Time

Favourable characteristic based on wave climatology
CFSR 1979-2012

Top 33%

Mid 33%

Bottom 33%



PW - Precipitable Water
W - Vertical Velocity (700-400hPa)
RV - Relative Vorticity (900-600hPa)
EA - Eastern Atlantic Precipitable Water

Brammer and Thorncroft (2014)

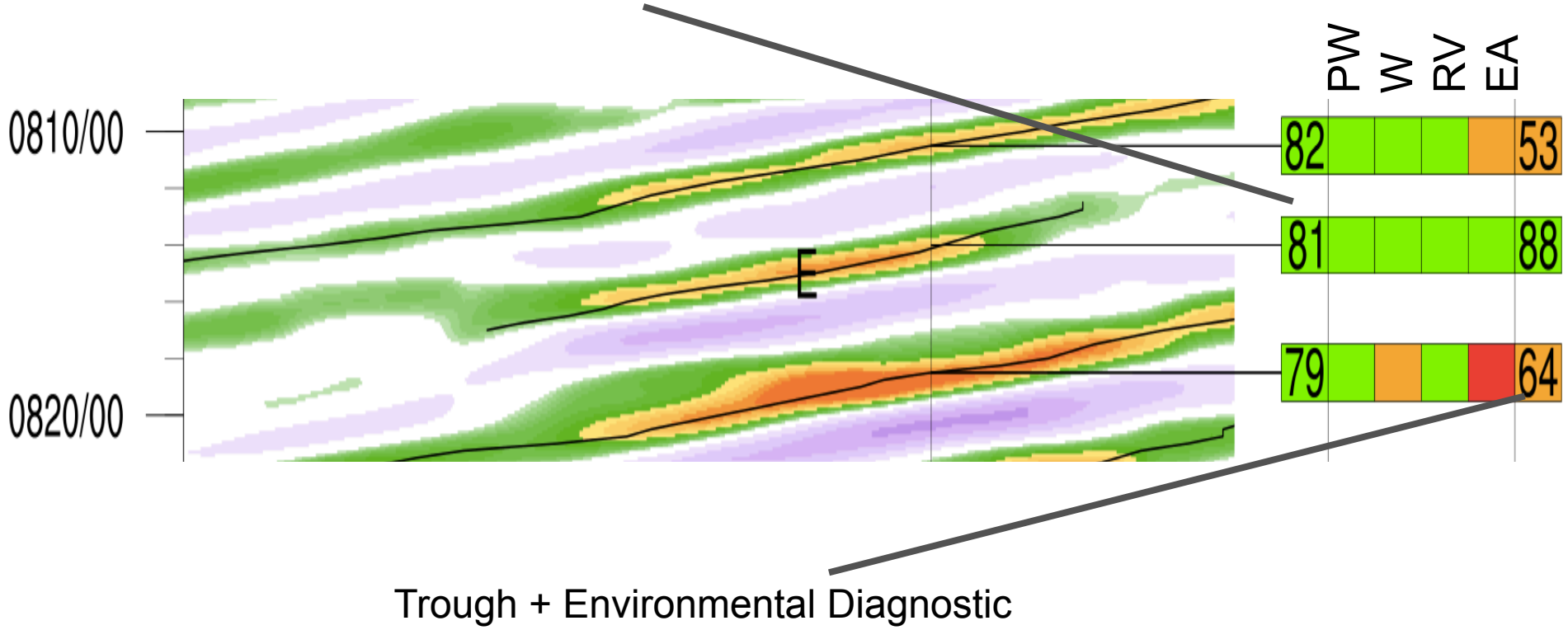
Monitoring AEW-quality in Real-Time

Based on Wave climatology

Top 33%

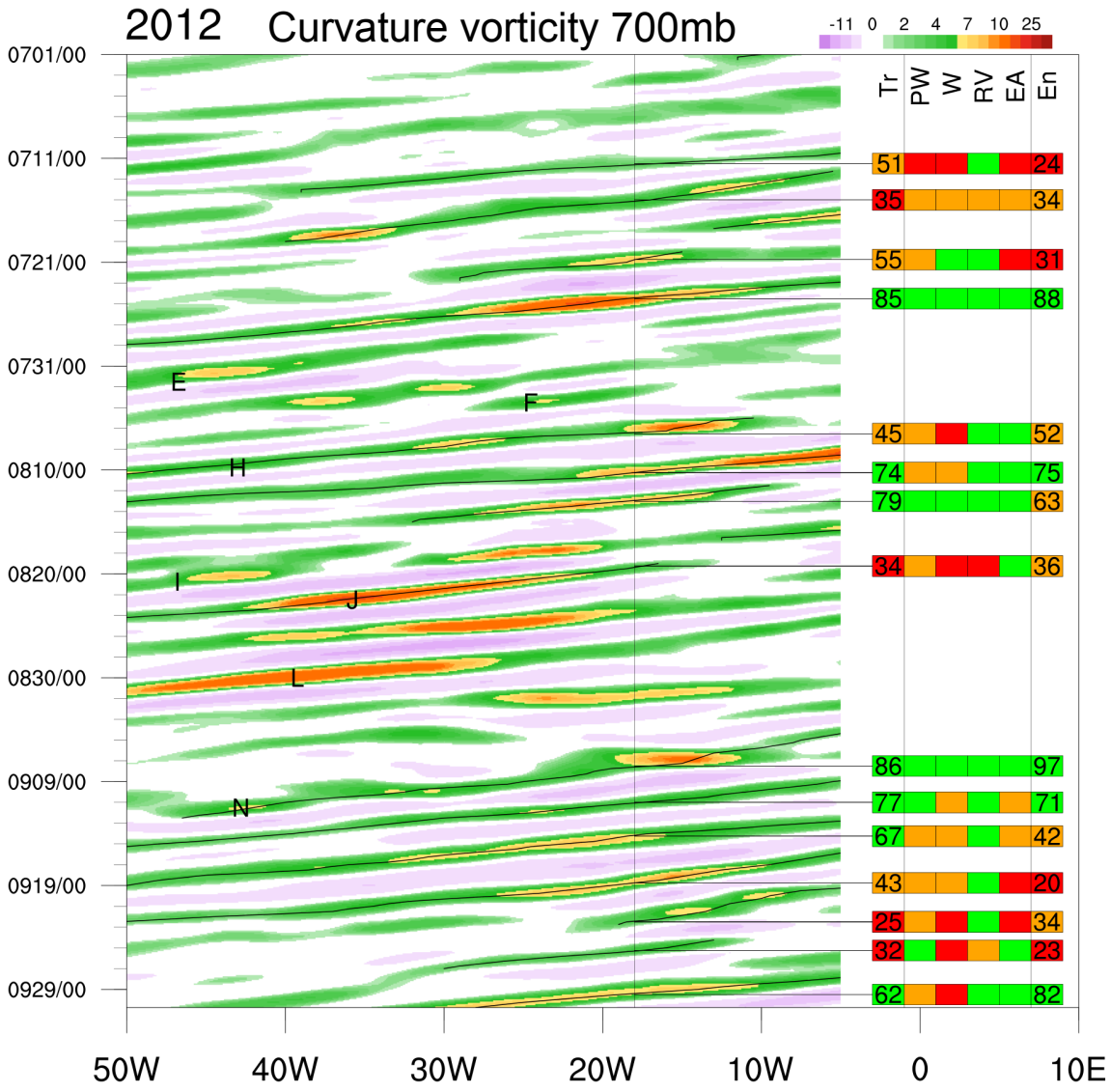
Mid 33%

Bottom 33%



Brammer and Thorncroft (2014)

Monitoring AEW-quality in Real-Time



Wave characteristics vary a lot during the season.

Brammer and Thorncroft (2014)